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52D CONGRESS, 2d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. 1, pt. 2, vol. II.

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ANNUAL REPORT

OF THE

CHIEF OF ENGINEERS,

UNITED STATES ARMY,

TO THE

SECRETARY OF WAR,

FOR

THE YEAR 1892.

IN FOUR PARTS AND ATLAS.

PART IV.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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APPENDIX W W.

ANNUAL REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

NEW YORK, *June 22, 1892.*

SIR: The Mississippi River Commission has the honor to submit this, its annual report, for the current fiscal year. Owing to the departure in June of its president, upon temporary duty in a foreign country, the history of its operations is brought down to May 31, instead of June 30, as usual.

Since the last annual report there have been no additional appropritions or legislation affecting the Commission. The distribution of the appropriations of last year, as given in that report, has been modified by the transfer of various sums from one object to another from time to time during the year, as the demand for funds in the various branches of the work became more or less pressing. To the previous allotments for levees was added the sum of $135,000, of which $75,000 was taken from Lake Providence Reach, $40,000 from general service, and $20,000 from the harbor at Helena, these latter allotments of $60,000 being made in the exigencies of the recent flood for the purpose of protecting the levees. To the previous allotments for harbors was added $48,000 for Greenville and $11,000 for Memphis, all taken from works of channel improvement, and $8,000 for New Orleans, taken from the Red and Atchafalaya rivers. Among the works of channel improvement the principal changes were the transfer of $247,000 from the previous allotment for Lake Providence Reach, of which $75,000 was given to levees, $50,000 to Plum Point Reach—diminished by $11,000 subsequently transferred to Memphis—$48,000 to Greenville, $48,000 to Ashbrook Neck—diminished by $6,000 subsequently transferred to Lake Bolivar Front—and $26,000 to plant, Third district. The sum of $1,000 was transferred from Helena to surveys, gauges, and observations, Fourth district, and $6,000 from Ashbrook Neck to Lake Bolivar Front. In the early portion of the year there had been a balance of $18,670 remaining unexpended of an allotment to Lake Bolivar from the appropriation of August 11, 1888. This was applied to levees, in addition to the sums already mentioned. Detailed financial statements accompany the report of the secretary of the Commission hereto attached.

Between July 1 and May 31 there were three meetings of the Commission—one in New York City, July 15–17, 1891, one on board its inspection steamer between St. Louis and New Orleans, November 5–18, 1891, and one on the same steamer between the same places May 4–10, 1892.

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SURVEYS, GAUGES, AND OBSERVATIONS.

Engaged in the general survey of the river, there were in the field at the date of the last report one triangulation and two leveling parties. The first party had reached a point 4 miles above Burlington, Iowa, working northward. It continued its work until July 28, 1891, when fieldwork was suspended at Port Louisa, Iowa, the additional distance covered being about 35 miles of river. This party was also charged with the establishment of lines of permanent bench marks across the valley. Triangulation work was resumed at Port Louisa, April 26, 1892, the party working northward. By the 31st of May it had reached Fairport, Iowa, a distance of about 22 miles from Port Louisa, making the total distance covered by new triangulation during the year about 57 miles. The triangulation is now completed from Donaldsonville, La., to Fairport, Iowa. Of the two leveling parties one had started from St. Paul, Minn., and working southward had reached Alma, Wis., and the other had started at Duluth, Minn., and working toward St. Paul had reached Sturgeon Lake. The former party continued its work until October 20, 1891, when fieldwork was suspended at Savanna, Ill., the additional distance covered being about 206 miles. The latter party continued its work until September 28, 1891, when fieldwork was suspended at St. Paul, the additional distance covered being about 102 miles. The line of precise levels had in previous years been made continuous from Biloxi, Miss., to Savanna, Ill., and thence to Chicago, Ill., connecting with Lake Michigan. The new work makes the line continuous to Duluth, and connects the whole with Lake Superior.

A party for topography and hydrography took the field early in August, beginning work near Alton, Ill., where the work of 1889 had terminated. They worked northward as far as Hannibal, Mo., a distance of about 118 miles by river. A considerable number of years having elapsed since the survey was made of the portion of the river below Cairo, it had become desirable to investigate the condition of the permanent marks. A party was sent out for that purpose in November, 1891, and between that time and March, 1892, went over the ground between Cairo, Ill., and Donaldsonville, La. Advantage was taken of this opportunity to make a reconnoissance and approximate location of the present shore lines, with a view to showing the amount of caving which has occurred since the general survey. A comparison of the two surveys gives the following interesting facts, viz: The total length of caving banks between Cairo and Donaldsonville, a distance by channel of 885 miles, is 921 miles. The rate of caving bears no relation to the degree of curvature of the bends, the maximum rate being found in comparatively straight reaches; nor is it influenced by the character of the vegetation on the banks, the shore line in a caving bend which is partly cultivated and partly timbered being smooth and regular, showing that the bend is eroded under both circumstances with equal facility. The quantity of soil thrown into the river by caving annually averages 9½ acres by 66 feet depth for each mile of river, or a total for the river between Cairo and Donaldsonville of 10 square miles by 86 feet in depth annually. Erosion does not necessarily mean a widening of the bed. The eroded bank is generally followed by an equivalent fill on the opposite bank, and in some localities of excessive erosion the bed has actually grown narrower. Further details of the comparison will be found in the report of Mr. J. A. Ockerson, assistant engineer, hereto appended. (See Appendix 4 F.)

In the office good progress was made in the preparation of the detail charts, scale 1:10,000, and of the topographical maps from Cairo north-

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ward, scale 1 inch to 1 mile. A plat of the triangulation of 1891 was made. Additional sheets, 11 in number, of the 1:20,000 charts were published, making 81 sheets in all which have now been published, covering the river from Donaldsonville, La., to just below St. Louis, Mo. Recomputation of discharge measurements made in 1891 was completed. The daily records of the gauges kept by the commission, and of certain others kept under Majs. Mackenzie and Miller, Capts. Willard and Taber, of the Corps of Engineers, and under the Weather Bureau and the Cincinnati waterworks, were received, tabulated, and printed. The record includes 32 gauges at various points upon the Mississippi, from Hastings, Minn., to Fort Jackson, La., and 23 gauges upon tributaries and 3 upon the Atchafalaya. For further details, see report of Capt Carl F. Palfrey, secretary of the commission. (Appendix 4.)

GENERAL SERVICE.

The "general service" was originally established with headquarters at St. Louis for the purpose of furnishing to the various districts such supplies as could not be procured within the limits of the districts and could not be conveniently obtained by the officers in charge of the districts by direct purchase. As the work advanced and markets were developed the duties of this branch of the organization were gradually restricted, until of late years they have been limited almost exclusively to supplying stone from the upper part of the valley to the first, second, and third districts. For several years past the office has been in the same building with that of surveys, gauges, and observations, and has been managed by the same officer, the secretary of the commission. At the end of the year the "general service" was discontinued.

There were shipped to the first and third districts 40,208 cubic yards of stone. Loaded at the quarry ready for shipment on May 31 were about 3,500 cubic yards more.

Necessary repairs were made to the fleet. All of the vessels are in serviceable condition except the steamer *Etheridge*, which is deficient in boiler power. A large number of the stone barges will probably require very extensive repairs before the end of another year.

COMMERCIAL STATISTICS.

An attempt to collect commercial statistics for the calendar year 1891 resulted in procuring some incomplete information upon the subject, which will be found in the reports of the secretary and the officer in charge of the first district.

FIRST DISTRICT.

(Cairo to foot of Island No 40, 220 miles.)

(*a*) *Columbus, Ky., 21 miles below Cairo.*—The work of improvement at this locality consists of five spur dikes, built in 1889–'90, under specific appropriations in the acts of 1886 and 1888 amounting together to $43,750, the object being to protect about 2,200 linear feet of bank which was threatening to cave. The work was completed last year. No injury to the spurs has been noted and no further work is at present required.

(*b*) *Hickman, Ky., 36 miles below Cairo.*—The acts of 1886 and 1888 contained specific appropriations for this locality, amounting together to $88,750. The evil to be remedied was the caving of the bank in front

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of the town. Owing to the existence of a projecting point of tough clay a short distance above the landing it was possible to accomplish the desired result with an unusually small development of work. A continuous revetment about 1,000 feet long, extending down stream from the clay point, was placed in October, 1890. Except for some slight damages by an eddy at the downstream end it remains in good condition, but requires additional stone ballast. The stone for this purpose has been stored near at hand and will be distributed over the revetment during the next low-water period. Above the clay point the caving continues, but there appears to be no public interest which is suffering sufficiently to justify the large expenditure, estimated at about $160,000, which would be required to protect that portion of the bank. Should the clay point finally yield, then additional expenditures will be required to maintain the work now in place.

(c) *New Madrid, Missouri, 71 miles below Cairo.*—To comply with the requirements of the act of September 19, 1890, as interpreted by the War Department, an allotment of $1,000 was made to this locality from the appropriation contained in that act, as reported last year, to be used in making a survey. The survey was made in September and October, 1891. There has been some caving of the bank in front of the town, which the inhabitants desire to have stopped. The cost of protecting the bank is estimated to be about $70,000. The commission is unable to recommend the diversion of any of the funds appropriated for the general improvement of the river to this purpose at this time.

(d) *Plum Point Reach, 147–186 miles below Cairo.*—The works thus far undertaken in this reach, arranged geographically, beginning at the upstream end, are: (1) Daniels Point revetment; (2) Ashport Bend revetment; (3) Gold Dust dikes; (4) Fletcher Bend revetment; (5) Dikes in chutes of Elmot Island and Island 30; (6) Plumb Point revetment; (7) Plum Point dikes; (8) Osceola Bar revetment; (9) Bullerton revetment; (10) Osceola and Bullerton dikes. They are distributed over a length of about 20 miles, some on one side and some on the other side of the river. They constitute one connected whole, each one being essential to the effectiveness of the others. The continued efficiency of all is dependent upon the maintenance of the conditions as to approach of the river from above which obtained when they were planned.

The order in which they were begun is different from the one just given, the object being first to obtain the desired results in the shape of a deepened channel and improved navigation, and then to maintain those results by repairs and extensions of the works themselves, and by the addition of such new works, higher upstream, as might become necessary. Thus the latest addition to the works is the one mentioned first on the above list.

(*d 1*) *Daniels Point revetment.*—Rapid caving having developed in the long bend known as Canadian Reach, of which Daniels Point is the foot, and there not being sufficient funds to undertake the protection of the entire bend when the appropriation of 1888 became available, it was determined to protect about a mile of the downstream end. As heretofore reported, a continuous revetment 5,300 feet long was placed. As a whole it has stood well, but the bend above it has continued to cave, giving to the upstream end of the revetment a salient position. It has suffered some damage at this point. An extension upstream 500 or 600 feet was required, and was contemplated this year. There was also a small break about 400 feet below the upstream end, and additional stone ballast was required over a considerable portion of the old work. Owing to the difficulty of procuring stone, it was found impos-

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sible to do all the work required this year. The break was repaired and additional ballast was placed, but the upstream extension had to be deferred.

(*d 2*) *Ashport Bend revetment.*—The protection of Ashport Bend was one of the first works projected in this reach. A short piece of revetment was placed in 1882, but more pressing demands for funds at other places prevented a continuation of the work until the present year. The bank had by this time receded so far that its protection had become imperative to avoid an injurious change in the action of all the works in Plum Point Reach. Operations were begun October 1 and continued until the middle of January, when they were suspended, having been greatly impeded by want of a sufficient supply of stone. Beginning at a point about 3,500 feet below Ashport, a continuous revetment was placed for a distance of 3,250 feet. It is proposed to continue the work during the coming year and to carry it to completion as soon as circumstances will permit.

(*d 3*) *Gold Dust dikes.*—No work done here and none contemplated. (See Annual Report for 1891.)

(*d 4*) *Fletchers Bend revetment.*—The protection of this bend was begun in 1884 and suspended in January, 1885, in an unfinished condition. Owing to restrictions contained in the act of 1886, by which expenditure of the funds appropriated in that act was prohibited for works of bank protection, this work could not be resumed until the autumn of 1888. It had then suffered some damage, but the most serious result of the suspension was the change in the form of the bend. Unprotected parts had caved back, leaving protected parts in a salient, and making the shape of the bend so awkward that it was deemed expedient to sacrifice the work protecting one of these salients. At the beginning of the present year the protection consisted of one piece of continuous revetment 7,800 feet long, beginning at the upstream end of the bend, then an interval about 4,000 feet long of unprotected bank, and of four detached blocks of revetment, each about 1,100 feet long, near the downstream end of the bend. The latter were separated from each other by intervals of 300, 400, and 500 feet, having been constructed in that manner as an experiment. The work this year consisted in extending the continuous revetment downstream to connect with the first of the detached blocks. Operations were begun in August and continued until February, when the project for the season was completed, except that the necessary quantity of stone could not be procured, and further ballasting remains to be done. Repairs also were made in the old work where needed. The indications now are that the interval between the two detached blocks of experimental revetment which are farthest downstream must be protected in order to save both pieces from destruction.

(*d 5*) *Dikes in chutes of Elmot Island and Island 30.*—Nothing was done to the original pile dikes and nothing is contemplated. (See Annual Report for 1891.) To complete the closure of the chute behind Elmot Island a submergeable dam of brush and stone has been projected and will be constructed as soon as circumstances permit. Some heavy masses of drift which accumulated against the remains of these dikes were sunk to aid in obstructing the flow through the chute. Compact mattresses of brush were placed over the drift and were then heavily ballasted with stone.

(*d 6*) *Plum Point revetment.*—Nothing done here during the year and nothing contemplated during the coming year. (See Annual Report for 1891.)

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(*d 7*) *Plum Point dikes.*—Nothing done here during the year and nothing contemplated during the coming year. (See Annual Report for 1891.)

(*d 8*) *Osceola Bar revetment.*—Rapid caving of the channel face of Osceola Bar, or Towhead, having begun, a continuous revetment of brush and stone was begun last year. It was continued this year. At the beginning of the year the revetment extended from the downstream end of the Towhead a distance of 4,500 feet upstream. Operations were resumed in October and continued until the latter part of November. The revetment was extended about 1,000 feet farther upstream, and was there terminated, any further extension being for the present unnecessary. The supply of stone being insufficient, the work was not carried as high up the face of the bank as is contemplated. Further ballasting is required here.

(*d 9*) *Bullerton revetment.*—Nothing was done here during the year and nothing is contemplated for the coming year. (See Annual Report for 1891.)

(*d 10*) *Osceola and Bullerton dikes.*—Nothing was done here during the year and nothing is contemplated for the coming year. (See Annual Report for 1891.)

Results in Plum Point Reach.—The river reached an unusually low stage during the months of October and November, though the minimum gauge reading at Fulton, Tenn., was not as low as in 1887, 1888, or 1889, and at Memphis it was not as low as in 1871, 1872, and 1888. A discharge of only 91,000 cubic feet per second was measured at Memphis, October 16, with the gauge 0.4 higher than the minimum, which it subsequently reached. The least depth found in the improved part of the reach was 6½ feet. It was found in the crossing between Gold Dust and Ashport Bar. Diminished depths were found in some of the other crossings. They are to be attributed to the large amount of channel-choking material thrown into the river by the caving of the banks, such as in Ashport and Fletchers bends, the protection of which had not been completed. The favorable results heretofore reported were not therefore fully maintained.

(*e*) *Surveys, gauges, and observations.*—Discharge observations were made at Cairo and Plum Point during the low-water period of 1891, and at Columbus, Ky., and Fulton, Tenn., during the high-water period of 1892. A hydrographic survey was made of the Plum Point Reach. A survey was made of Hickman Harbor in October. The survey at New Madrid has already been mentioned.

(*f*) *Levees.*—The only levees constructed by the United States in the first district are the two short detached pieces in the vicinity of the Plum Point Reach, built in 1886–'88. Nothing was done to them during the year. (See Annual Report for 1891.) There is no general system of levee maintained by local authorities within the limits of this district.

For details of the operations in the first district, see report of Capt. S. W. Roessler, hereto appended (Appendix 5).

SECOND DISTRICT.

(Foot of Island No. 40 to mouth of White River, 180 miles.)

(*a*) *Memphis, 230 miles below Cairo.*—Works for the protection of the harbor at Memphis include the protection of the city front, and of Hopefield Bend, above and on the opposite side of the river. The latter

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work was begun in 1882, but for the reasons given in former reports it could not be completed until February, 1889. By that time the downstream end of the bend had receded so far that the approach of the river to the Memphis landing was no longer favorable to the maintenance of the upstream portion of the landing. A bar had formed here in front of the landing, where there are some important business interests, such as the grain elevator and railway transfer. During the low-water season of 1891 a channel was dredged through this bar, as in previous years, and there was no interruption of steamboat traffic to the elevator.

The damage to the revetment of Hopefield Bend, noted in the last Annual Report as having been inflicted by the high water of 1891, proved to be more serious than was then supposed. After the river had fallen two breaks were discovered, one about 2,750 feet long at the head of the 1884 work; the other about 600 feet long in the 1887 work and just above the repair work of 1890. The necessary repairs were begun in September and completed in January. Besides restoring the revetment at the places just referred to, additional stone ballast was placed where it was deficient at other places. During the present high water there have been two new breaks, one of them in the new work placed this year. The extent of these breaks is not accurately known, but appears to be moderate. It is proposed to repair them during the coming season.

The protection of the city front was begun in 1878, before the organization of the Commission, at the upstream end of the landing. With the changes in Hopefield Bend the point of attack has moved downstream and the protection has from time to time been extended in that direction. The most recent work is the system of spur dikes, known as the "Citizen's Protection," originally built in 1886 with funds subscribed by property owners in the vicinity, the work being executed under the direction of the officer in charge of the district with plant belonging to the United States. They were raised and covered with stone by the Commission in 1889. They, as well as the revetments higher upstream, remain in serviceable condition, but there has been a decided settlement of the dikes. After the high water of 1891 a subsidence amounting to about 4 feet vertical was noted, but without lateral movement towards the channel. Caving continues slowly along the bluff further downstream.

(*b*) *Helena, 306 miles below Cairo.*—Nothing was done here during the year. See Annual Report of 1891.

(*c*) *Surveys, gauges and observations.*—Discharge observations were made at Memphis and Helena during the low-water period of 1891, and at Helena during the high water of 1892. A survey was made of Memphis Harbor in October, and one of Nonconnah Rock in the same month. The report of the latter survey is hereto appended. A survey was made also for a new levee behind Lake Charles (357 L), as the caving at the head of the lake and below it in the vicinity of Andersons Landing and Pushmataha has approached so close to the existing levee that new and extensive loops will be necessary or a new levee behind the lake.

(*d*) *Levees.*—The levees in the second district include on the right bank the White River front, which extends from Helena to and including Laconia Circle, a distance of about 78 miles by river, and on the left bank so much of the Yazoo front as lies within its limits, a distance by river of about 120 miles. The lengths of levee are much shorter than these distances. Work was carried on during the year to a small extent upon both fronts.

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(*d 1*) *White River Front.*—Upon the White River Front at the beginning of the year a levee extended southward from Helena a distance of about 15½ miles, and another extended northward from Laconia Circle, leaving a gap between them of about 30 miles, in which there was no levee except the old and badly broken-up State Levee. During the year the Helena Levee was extended southward 28,338 feet, of which 5,000 feet was enlargement of an old levee and the balance new work. It was built with a crown of 8 feet, side slopes 1 on 3, and grade 3 feet above highest known water (1890.) The Laconia section was extended northward 4,240 feet, with crown 8 feet, side slopes 1 on 3, and grade 4 feet above highest water of 1890.

(*d 2*) *Upper Mississippi Levee District.*—Upon the Yazoo Front the work consisted in enlarging the existing levee above Hushpuckena (352 L) to a height of from 3 to 4 feet above highest water, with a crown of 10 feet and land slope of 1 on 3. In addition to this much work was done by the local authorities, the amount and location of which has not been reported to the Commission. Allotments have been made to this district under the title Upper Mississippi Levee District.

THIRD DISTICT.

(Mouth of White River to Warrenton, Miss., 220 miles.)

(*a*) *Lake Bolivar Front, 417 miles below Cairo.*—Nothing was done here during the year. The work has accomplished the object for which it was built and remains in good condition, except that additional stone ballast is required above the water surface, which it is intended to supply at an early day. See Annual Report for 1891.

(*b*) *Ashbrook Neck, 446 miles below Cairo.*—As explained in the last Annual Report, the protection of the upstream side of Ashbrook Neck had become necessary in order to prevent a cut-off. The work was begun in 1890. At the beginning of the present year 2,820 linear feet of revetment had been placed at the narrowest part of the neck, but the lower 500 feet of it having been constructed during a high and rising river, was of insufficient width and had suffered some damage. Operations were resumed in August and continued until January, when they were suspended on account of high water. The old work was repaired and was then extended downstream a distance of 2,500 feet. An extension upstream was begun and was carried a distance of 1,300 feet. Further extension in that direction is contemplated. To prevent flow across the neck at high water a levee was constructed near the axis of the neck. It has suffered material injury during the present high water.

(*c*) *Greenville, Miss., 478 miles below Cairo.*—The work at this place, begun in 1887, had for its object the protection of the bank in front of the town, which was caving rapidly. A sketch of the operations to the beginning of the present year is given in the last Annual Report. At that date the original protection of the town front had been taken in flank by the continuous caving of the bend above, and the upstream end of it had been destroyed. The necessity of protecting the bank just above the town was urgent. It was undertaken as soon as the stage of the river would permit. Operations were resumed in August and continued until January, when the project for the year was completed. A continuous revetment 6,600 feet long was placed, extending upstream from the upper end of the portion of the original work, which remained intact. As was stated last year, the certain way to protect Greenville is to protect the bend above throughout its whole length.

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The amount of funds required for that have not been available. The work done this year should afford relief from immediate danger. It seems probable that further extensions of the revetment may be necessary in the future.

(*d*) *Lake Providence Reach, 517 to 552 miles below Cairo.*—A brief sketch of the operations in this reach, from the time when they were begun in 1882, was given in the last Annual Report. It then appeared that, for reasons beyond the control of the Commission, the earlier works had either been destroyed or had become uncertain in their action, and that although the beneficial results obtained by them still remained, the river throughout the reach was not under control, and there was no certainty that the results were permanent. A systematic and permanent improvement involved the construction of a new series of works, beginning with Louisiana Bend, at the head of the reach. A new protection of this bend was begun in 1889 and completed for a length of 6,024 feet. At the beginning of the present year this work was in good condition, except about 200 linear feet at the downstream end which had been injured by the erosion of the bank below it. Operations were resumed in September and continued until the latter part of January. The damaged lower end of the old work was replaced and the revetment extended 5,000 feet, making 5,224 linear feet of revetment placed this year. The total length of revetment in Louisiana bend is 11,024 feet, all of it standing intact. It is proposed to extend the work during the coming year.

(*e*) *Vicksburg, 599 miles below Cairo.*—The works for the maintenance and improvement of Vicksburg Harbor consist, first, of the revetment of Delta Point, to prevent its further recession, which would allow the river to abandon the present Vicksburg front entirely instead of partly, as is now the case; and, second, of a dredged canal leading to a dredged basin at the upstream part of the city front.

The Delta Point revetment, covering 10,700 linear feet of bank, was constructed between 1878 and 1884. It has required no repairs for several years. The subaqueous portion is still in good condition, but the upper bank portion is in places in need of stone ballast to replace the brush which has rotted. It is proposed to place the necessary stone during the coming year. Higher upstream the bank continues to cave slowly, and it will probably be necessary to extend the revetment in that direction in the future, but it is not evident that that will be required during the coming year.

At the beginning of the year the canal had been excavated approximately to the plane +8 feet on the Vicksburg gauge and dredging was in progress. It was continued until September 7, when it was suspended on account of low water. At that time the canal had been excavated to a plane between +5 and +6 feet on the Vicksburg gauge. A greater depth had been anticipated from the season's operations, but a heavy deposit from the river occurred during the high water of the previous spring and summer, against which the dredge had to work. Dredging was resumed February 8, 1892, and on the 15th of May was still in progress. At the latter date one cut 40 feet wide through the canal had been excavated to a plane zero on the gauge and another cut to the same depth partly through. The amount of material excavated during the year was 315,079 cubic yards. The amount previously excavated in canal and basin was 954,514, making the total amount of excavation since 1888, when the work was begun, 1,269,593 cubic yards, measured in the scow. The excavated prism now existing should have involved the excavation of 1,020,800 cubic yards, measured in the scow, had there been no fill from deposits by the river. The dif

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ference, or 248,793 cubic yards, measures the amount of the deposits in four years.

(*f*) *Surveys, gauges, and observations.*—Discharge observations during the low water of 1891 were made at Wilsons Point in October, and during the high water of 1892 at Arkansas City and Wilsons Point. Surveys were made near Ashbrook Neck, Greenville, and Louisiana Bend while the works were in progress. In October a hydrographic survey was made of Lake Providence Reach and one in the vicinity of Pecan Grove, to note the changes, if any, due to the Raleigh crevasse of 1890.

(*g*) *Levees, east bank Lower Mississippi levee district.*—On the east, or left, bank of the river the levees in the third district extend from opposite the mouth of White River to Eagle Lake, covering the lower half of the Yazoo Basin, a distance by river of about 190 miles. The length of the levee line is much shorter, being about 167 miles. It covers the local organization known in the allotments as the Lower Mississippi levee district, and overlaps for 28 miles upon the local Upper Mississippi levee district. The small amount available for levee construction was devoted to strengthening the levee at Catfish Point (423 L) and building loops to cover breaks in the line at Greenville (478 L), Stella (502 L.), and Shipland (543 L). The total yardage placed by the Government was 288,072 cubic yards. The local authorities, the Lower Mississippi levee board, placed during the year 1,896,518 cubic yards at various points not reported to the Commission. An estimate was given last year of the yardage required to raise the levees in this district to a height 3 feet above the calculated high water of 1890. It is possible that the experience of this year may cause the standard to be changed. The State authorities have made strenuous efforts to strengthen their line. Their levees have generally a width of crown of 8 feet, with crests at least 2 feet above the flood of 1890.

(*h*) *Levees, west bank.*—On the west, or right, bank of the river the levees in the third district extend from Amos Bayou, about 17 miles north of Arkansas City, along Cypress Creek, to Lucca Landing, on the Mississippi, and thence to the southern limit of the district, covering the upper half of the Tensas Basin, a distance by river of about 181 miles. The length of the levee line is about 173 miles, of which 84.8 miles is in the State of Arkansas and the remainder in Louisiana. The local levee organizations are the Desha County levee board, the Chicot County levee board, both in Arkansas, and the Fifth Louisiana levee district. The Tensas Basin levee district, a Louisiana organization, is authorized by the law of its State to expend money in Arkansas Tensas Basin. Allotments for levees on this bank have been made under the titles "Levees Tensas Basin. Arkansas," and "Levees Tensas Basin, Louisiana, third district.

(*h 1*) *Tensas Basin, Arkansas.*—The old levees of Arkansas are generally of flimsy character, the prevailing type through the district having a crown of about 4 feet and height about that of the flood of 1890. The local boards have barely sufficient revenue to keep them in repair. Most of the efficient work done of late years in the district has been done by the United States or the State of Louisiana. At the beginning of the present year the extension of the Lucca loop (428 R) was under construction. It was duly completed. With the small amount available for levee construction this year the levee at Opossum Fork (427 R) was enlarged, and loops were built at Sunnyside (491 R), Cracraft (513 R), a spur constructed on Leland short line (470 R), and the enlargement of the levee below Lower Boggy Bayou (445 R) was begun. The total yardage placed by the United States was 270,377 cubic yards. The Desha County levee board enlarged the levee in

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front of Arkansas City, placing 19,235 cubic yards. The Chicot County levee board constructed levees at Luna (467 R), Leland (483 R), and enlarged those at Bellevue front (466 R) and at Sterling (515 R), the yardage not being reported to the Commission. The Louisiana authorities, compelled for their own protection to go beyond the limits of their State, enlarged the levee from Chicot (432 R) to Arkansas City, placing 148,638 cubic yards. They also contributed 45,611 cubic yards to the Lucca loop (428 R), built mainly by the United States.

(*h 2*) *Tensas Basin, Louisiana, third district.*—With this year's allotment for this subdistrict a levee was built at Illawara (562 R), containing 349,241 cubic yards.

For details of the operations in the third district see report of Capt. C. McD. Townsend, hereto appended, Appendix 6.

FOURTH DISTRICT.

(Warrenton, Miss., to Head of Passes, 484 miles.)

(*a*) *Natchez and Vidalia, 700 miles below Cairo.*—A history of Congressional and executive action with reference to this locality was given in the last Annual Report. Nothing was done here during the year.

(*b*) *Rectification of the Red and Atchafalaya rivers, 764 miles below Cairo.*—The project adopted for this locality has for its object (1) to limit the outlet capacity of the Atchafalaya, and (2) to improve the low-water navigation from the Mississippi into the Atchafalaya, and also into the Red River.

The first of these objects is to be accomplished by the construction of a series of dams in the Atchafalaya, submerged sufficiently to permit navigation over them. At the date of the last Annual Report two of the projected dams, Nos. 1 and 3, built in 1888 and 1889, had been constructed near Simmesport, in the Atchafalaya, about 5 miles below its head. They remain in good condition. Nothing further was done here during the year.

The second object is to be accomplished by replacing the present single channel between the Mississippi and the Red-Atchafalaya, through which the flow is sometimes in one direction, sometimes in the other, and sometimes does not exist at all, by two channels, one for the inflow from the Red to the Mississippi, and the other for the outflow from the Mississippi to the Atchafalaya, and to prevent the Red River, at low water, from wasting itself down the Atchafalaya, by a dam which shall separate it from that stream at low and medium stages. One of these channels is furnished by the present single channel, called Lower Old River, south of Turnbull Island. The other is to be created by the enlargement of Upper Old River, north of Turnbull Island, for the greater part of its length, until it reaches the vicinity of Carrs Point, and then continuing it to a junction with the Mississippi by excavation through Carrs Point.

The difficult part of this project is the excavation of the channel north of Turnbull Island. The old waterway has much diminished in size in the last few years until now a narrow chute, which is dry in places at a 12-foot stage, is all that remains of it. Several million cubic yards of material must be removed. The material is soft mud, in which a trench is difficult to maintain, the semifluid sides flowing into it with great facility. A small amount of dredging was done last year, as noted in the last Annual Report, and operations of that kind were resumed in the early part of the present year; but a very brief experience was sufficient to demonstrate that the appliances at the disposal of the Commission were not adapted to the circumstances of this case.

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Dredges of much greater capacity were required. Operations were promptly suspended, and an investigation of the resources of the country in dredging appliances was entered upon, with a view to procuring the most efficient one for this purpose which exists or can be constructed. Specifications were finally prepared, and proposals for furnishing an efficient apparatus were invited by public advertisement dated June 1, proposals to be opened on the 1st of August next. To aid in the excavation of this channel it is very desirable that a current from Red River be forced through it as soon as practicable. This could be accomplished by building to a sufficient height the dam designed to separate the Red River from the Atchafalaya, known in this project as the Red River Dam. But the Commission did not feel at liberty to obstruct the navigation which now passes over the site of that dam before providing a new channel. The dam was begun in 1889 and at the beginning of the present year it had been built up until its crest was from about 1 to 3 feet below low water. It was the intention up to the time when dredging in Upper Old River was suspended to continue the construction of the dam to a moderate height above low water, so as to obtain some assistance from it if possible in the way of a current through the new channel, but at the same time to keep it so low that in case of a very low-water season a portion of it could be cut down, and a channel through it preserved, without too great a loss of material. The work of construction was continued in the early part of the present year. When dredging was suspended orders were given to suspend work upon the dam also, as soon as convenient, but to use up such material as had been accumulated. Its crest when work was suspended was about 3 feet above low water. The river subsequently fell to a very low stage and a portion of the dam was removed in compliance with orders given before it was built, in anticipation of such a contingency. There is now an opening through it about 450 feet wide and 5 feet deep at low water. Otherwise it is in good condition.

It is evident that the execution of this project is much hampered by the necessity of not obstructing the use of the stream by navigation. The navigation interest has this spring very generously come to the aid of the Commission. In a communication signed by all, or nearly all, the masters, owners, mates, and pilots of boats engaged in trade to the Atchafalaya, Red, and Ouachita rivers, they have urged that the approved project be pushed to completion, that the Red River Dam be raised so as to force the Red River to flow north of Turnbull Island and of itself create that channel, and have voluntarily offered to relinquish the use of the old channel thus obstructed. The Commission has not thought it best to accept this offer at this time, believing that both dredging and a current are necessary. It is proposed to resume operations when a satisfactory dredging outfit is secured, and sufficient funds are available, and then to take advantage of this offer.

The usual difficulties were experienced in maintaining a navigable channel through Lower Old River during the low-water period. Dredging was begun as soon as the water had fallen sufficiently to permit the dredges to work and was continued until the water was too low to float them. By October 6 the channel had become impassable for the regular steamboats, though small light draft boats continued to go through and transfer freight until October 30. At that time all navigation was suspended and it so remained until November 27, when both the Red and the Mississippi rose rapidly and navigation was restored.

The telephone line, 30 miles long, to connect with West Melville, the nearest railway station, the construction of which was begun last year, was completed.

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(c) *New Orleans Harbor, 963 miles below Cairo.*—The city of New Orleans covers a length of about 13 miles of the Mississippi River. In that distance the river makes four bends, called the Carrollton, Greenville, Gouldsboro, and Third District bends. In all of them more or less erosion was going on, which, as the value of property increased, it became desirable to stop. The features of the case, which are peculiar and make it different from other places where the protection of banks has been undertaken, are (1) the great depth of water and steepness of the banks, which are unfavorable, and (2) the comparative stability of the banks, which has enabled New Orleans to occupy essentially her present site for a century and a half, which is favorable. The system of spur dikes was introduced in 1884, and has since been used exclusively, and has thus far been successful. The spurs begin near the low-water line and project into the river to the point where their top surfaces, having a slope of 1 upon 3, intersect the bottom. They are usually about 1,000 feet apart, but the interval may vary with the greater or less curvature of the bend.

At the beginning of the present year there had been placed in New Orleans Harbor 3 spurs in the Carrollton Bend, 2 in the Greenville Bend, 6 in the Gouldsboro Bend, and 4 in the Third District Reach, a little below the bend. During the year 4 additional spurs were built in the Third District Reach and 2 in the Carrollton Bend. They were all in good condition at the end of the year, and appear to be accomplishing the object for which they were designed. The construction of additional spurs is contemplated.

(d) *Surveys, gauges, and observations.*—Discharge observations during the low water of 1891 were made in the Mississippi at Red River Landing, in the Atchafalaya near Simmesport, and in the Red River at the Red River Dam, and during the high water of 1892 in the Mississippi at Natchez, Red River Landing, and Carrollton, and in the Atchafalaya at Simmesport. Local surveys were made in the vicinity of Red River Dam and at five places in New Orleans Harbor, and in connection with the location of new levees, and a continuous line of levels was run over the levees of the Tensas Front from the upper end of the district down to Fairview Landing.

(e) *Levees.*—The levees in this district include the lower half of the Tensas Basin and the Atchafalaya Basin on the right or west bank, a distance by river of about 432 miles, and on the left or east bank, the low country below Baton Rouge, a distance by river of about 206 miles. The local organizations for the right bank are (1) Fifth Louisiana levee district, extending from the State line to the mouth of Red River, (2) Atchafalaya Basin levee district, extending from the mouth of Red River to Donaldsonville, (3) Third Louisiana levee district, extending from Donaldsonville to the Gulf of Mexico, except about 13 miles at New Orleans. Those for the left bank are (1) Pontchartrain levee district, extending from Baton Rouge to the upper limit of the city of New Orleans, and (2) First Louisiana levee district, extending from the lower limit of the city of New Orleans to the Gulf of Mexico. The Orleans levee district includes all levees on both banks within the limits of the city of New Orleans, extending about 13 miles on each bank. Allotments by the Commission have been made under the titles "Tensas Basin, Fourth district," "Right bank below Red River," and "Left bank below Red River."

(e 1) *Tensas Basin, fourth district.*—At the date of the last Annual Report the levee which had been begun at Gibsons Landing (683 R) was not completed. It was finished this year. The levee at Henderson (712 R), which had been contracted for last year, was built this

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year. In addition to these the following lengths of levee were constructed, viz: 9,840 feet at Hardscrabble (639 R), 11,632 feet at Kempe (659 R), and 136 feet at the Ferriday crevasse (693 R), containing in all 399,831 cubic yards. They were built with a crown of 8 feet, side slopes 1 upon 3, and to a height from 1½ to 3 feet above high water of 1890. Work was done by the local authorities, the amount and location of which has not been reported to the Commission.

(*e 2*) *Right bank below Red River.*—After completing the levees which were reported as under way at the date of the last Annual Report, the following lengths of levee were constructed, viz: 600 feet at Nina (806 R), 8,021 feet extension at Highland (815 R), 4,743 feet at Mayflower (853 R), 3,686 feet at Fortville (855 R), 3,400 feet at Evergreen (857 R), and 783 feet at Dumboine (865 R), containing in all 435,550 cubic yards. They were built with a crown of 8 feet—except at Nina, where it was 6 feet—side slopes of 1 upon 3, and to a height of from 1.2 to 3 feet above high water of 1890. Repairs were made to the levees in various places, removing weeds, replacing sods and restoring slopes damaged by rain wash. Work was done by the local authorities, the amount and location of which have not been reported to the Commission.

(*e 3*) *Left bank below Red River.*—In this subdistrict the following lengths of levee were constructed, viz: 9,258 feet at Southwood (extension) (875 L), 1,959 feet at Tessier-Bourgeois (909 L), and 1,372 feet at Southport (955 L), containing in all 165,911 cubic yards. They were built with crowns of 8 feet, slopes 1 upon 3, and to a height 2½ to 3 feet above high water of 1890. Repairs were made at various places.

For details of the operations in the Fourth District, see report of First Lieut. John Millis, Appendix 7.

HIGH WATER OF 1892.

The high water of 1892, though of unusual height in the upper Mississippi—at St. Louis not having been equaled since 1858—was not of excessive height in the upper part of the main trunk below Cairo. As far down as Helena, 306 miles below Cairo, and for some distance below that, it has been exceeded half a dozen times in the last ten years. Below the Arkansas River it was the highest upon record. One of its remarkable features was the lateness of the season at which it occurred. In some cases the highest stages were not reached until after the date, May 27, at which the executive officers of the Commission rendered their annual reports. Later information seems to indicate that the maximum stage of the river has been passed, but at this writing, June 16, the water is still very high, having fallen but a few inches from the highest stage reached, referring always to the portion of the river below the Arkansas.

The information before the commission concerning the flood is at present incomplete. It seems probable that the maximum strain has been placed upon the levees which they will have to bear this year, and that but little, if any, further damage will be suffered by them. Only a very general view of what these damages are can now be given. The number of crevasses has been somewhat greater than the number last year, though insignificant compared with the number in former years of great floods. A large part of the Tensas basin in Arkansas is overflowed. There has been no break anywhere on the Yazoo front or on the Atchafalaya basin front or in the Orleans district. The local organizations in those districts had made more serious efforts to strengthen their levees than had the local organizations elsewhere. Crevasses have occurred in the Pontchartrain district and in the First

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and Third Louisiana districts, but at this writing it is not known how extensive the overflow from them is. The district officers have been untiring in their efforts to hold the levees. Upon the approach of the flood the engineering staff was stationed at critical points, sacks and lumber were distributed, and steamers required for transportation and inspection were employed. In coöperation with the local authorities, the weakest levees have been under constant inspection and many repairs have been promptly made as required. That these efforts have not in all cases been successful should not be surprising. The levees require an expenditure of several million dollars to put them in a state of reasonable security against great floods. That they should yield in places during the highest flood heretofore recorded is to be taken as a matter of course.

LOW WATER OF 1891.

The stage of the river in October and November, 1891, though not the lowest upon record, was so low as to seriously obstruct commerce. Most of the steamboats and barges were laid up, and such as continued to run were compelled to carry greatly reduced loads. The large grain crop of this country and the great demand for it in Europe rendered this an unusually serious misfortune. Millions of bushels of wheat which had been sold in Europe were lying in the elevators of St. Louis, without means of transportation, while the grain barges were tied up at the bank. Urgent demands were made upon the commission for relief, by a temporary removal of the crests of the most prominent bars by dredging, and several devices for accomplishing that result, very easily as the designers supposed, were presented. The idea of procuring temporary relief to navigation during the low-water period at a small cost is a very attractive one and has at one time or another engaged the attention of probably every engineer, including the commission, who has been employed upon the river. It would seem at first glance to be a simple matter to shave off the crests of a few of the more prominent bars and thus materially increase the draft to which vessels may load. Long's scraper and the portable wing dam of Adkins and Keiser are among the devices to accomplish this object which have been built and tried and have failed, while those which have been designed and proposed are innumerable and of every description. The difficulty in applying successfully any of these devices lies in the great building power of the river, the inconstancy of its flow, and its great width. It is essential that the device, whatever it be, shall not oppose the tendency of the river, but shall aid it. In a river a mile or two wide, with perhaps several channels of equal dimensions, it will often be difficult to tell by casual observation which one of these channels it is tending to enlarge or abandon. The tendency one day may be reversed the next by a sudden rise or fall in the river's stage. Hence the commission has never been sanguine about the possibility of obtaining useful results from experiments with dredging appliances in the Mississippi. It condemns without hesitation all devices which rely exclusively upon the current of the river for carrying away the excavated material. However useful such devices may have proved upon small streams, upon bars of moderate dimensions, no good results can be expected of them in the Mississippi, where the distance across the bar is often a mile or more. Likewise, it condemns all appliances of small capacity, such as the dredges to be found in ordinary use. Where hundreds of thousands of yards of material must be moved, and moved promptly, some quicker and cheaper appliances than those are needed. In the judgment of the commission some dredge of great capacity, which can

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remove the material bodily and can itself be easily moved from place to place, is essential in order to give a reasonable chance of success.

In view of the very serious loss which the trade of the valley was suffering from the obstructions of last autumn, the commission, though not very sanguine, was willing to try the experiment of dredging, provided a dredge such as it considered essential could be secured. There was but one such in the Mississippi River, the dredge *Bailey*, employed at the South Pass. Efforts were made to obtain her, but they were fruitless, her services being required by her owners at the South Pass. The commission has had under consideration the propriety of building a dredge for this experiment, but in view of its very considerable cost has not yet concluded to do so.

The obstructions during the low-water season were of course greatest above Cairo. Between Cairo and the mouth of White River, there were 42 crossings giving less than 10-feet channel depth, of which 35 had less than 9 feet, 26 less than 8 feet, 21 less than 7 feet, 8 less than 6 feet, and 1—at the head of Island 40—had 5 feet.

FINANCIAL STATEMENTS.

Appropriation for salaries and expenses Mississippi River Commission:	
Balance on hand July 1, 1891	$80.91
Refundment by Capt. Powell, for account Mississippi River Commission	57.35
Balance on hand May 31, 1892	138.26
Appropriation for survey of Mississippi River:	
Balance on hand July 1, 1891	7.08
Balance on hand May 31, 1892	7.08
Appropriation for improving Mississippi River:	
Balance on hand July 1, 1891	3,056,079.99
Expended July 1, 1891 to May 31, 1892	2,069,704.81
Balance on hand May 31, 1892	986,375.18
Distributed as follows:	
Levees	78,118.46
Channel works	314,867.22
Harbors and bank protection	281,116.02
Red and Atchafalaya rivers	89,871.73
Surveys, gauges, and observations	57,084.23
Plant, general service, and miscellaneous	165,317.52
Total	986,375.18
Approximate outstanding liabilities and amounts covered by existing contracts	249,046.98

C. B. COMSTOCK,
Col. of Engineers and Bvt. Brig. Gen.,
President Mississippi River Commission.
CHAS. R. SUTER,
Lieut. Col. of Engineers.
B. M. HARROD,
R. S. TAYLOR,
O. H. ERNST,
Major of Engineers, Col. U. S. Army.
HENRY FLAD, C. E.,
HENRY L. WHITING,
U. S. Coast and Geodetic Survey.

The SECRETARY OF WAR,
Through the Chief of Engineers, Washington, D. C.

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LETTERS OF THE MISSISSIPPI RIVER COMMISSION SUBMITTING ESTIMATES FOR THE FISCAL YEAR ENDING JUNE 30, 1894.

ST. LOUIS, MO., *August 16, 1892.*

GENERAL: Your letter of August 4, calling for estimates from the Mississippi River Commission for the fiscal year ending June 30, 1894, failed to reach me in time to be laid before the Commission at their recent meeting.

It was supposed by the Commission that estimates in the usual form would not be required, since the act of July 13 specifically designated the amount which can be expended during each of the four years provided for. It was, however, supposed that a recommendation covering a detailed project for this expenditure would be required before the next meeting of Congress, and instructions were given to the secretary and to the district officers to have projects prepared for works under their charge in time for the next meeting of the Commission, November 5, 1892. As these projects are intended to cover the whole amount allowed by law for the year ending June 30, 1894, after deducting the $1,500,000 already recommended for expenditures on levees during that year, the gross estimate of the Commission for the fiscal year ending June 30, 1894, may be placed at $2,665,000. Separate estimates for continuing work on harbors have already been submitted.

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Lieut. Col. of Engineers,
Acting President, Mississippi River Commission.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

THE MISSISSIPPI RIVER COMMISSION,
New York City, August 8, 1892.

GENERAL: In compliance with the requirements of the river and harbor acts of 1866 and 1867, I have the honor to submit estimates for improvement at certain points on the Mississippi River, for the fiscal year ending June 30, 1894, viz:

At New Madrid, Mo	$45,000
At Memphis, Tenn	75,000
At Greenville, Miss	200,000
At Vicksburg, Miss	100,000
At Natchez, Miss., and Vidalia, La	400,000
At New Orleans, La	100,000
For rectification of Red and Atchafalaya rivers	300,000

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Lieut. Col. of Engineers, President pro tem.,
Mississippi River Commission.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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LIST OF APPENDICES ACCOMPANYING THE FOREGOING REPORT.

LIST OF PLATES ACCOMPANYING THIS REPORT.

* Not printed.

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APPENDIX 1.

REPORT OF LIEUTENANT COLONEL CHARLES R. SUTER, CORPS OF ENGINEERS, UPON EFFECTS OF AMES CREVASSE, MARCH 16, 1891.

ST. LOUIS, MO., *June 14, 1892.*

GENERAL: I have the honor to submit herewith a diagram which exhibits graphically the effects of the Ames crevasse, which occurred opposite New Orleans on March 16, 1891. The diagrams are prepared in a manner entirely similar to those which were submitted to the Commission last year to illustrate the effects of the "Nita" and other crevasses which occurred below Red River in 1890.* The present instance is very interesting, as it was the only crevasse that occurred, and hence there are no complications of the effect produced. Bayou Sara is taken as the upper station on this diagram, as the effect of the crevasse did not extend above Baton Rouge. In the accompanying tabulation are given for each station the maximum effects of the crevasse, that is to say, the difference between the heights which theoretically should have been produced by the maximum reading at Bayou Sara, and the readings which actually did correspond to it. The maximum reading at Bayou Sara occurred on May 1, the crevasse having taken place March 16.

The effect of this large crevasse, which discharged very nearly 100,000 cubic feet per second, died out completely at Baton Rouge, 126 miles upstream, and after running for six weeks it had only relieved the river at Carrollton, 2 miles above, to the extent of 1.9 feet. If the crevasse had not occurred the Carrollton gauge would have reached an elevation of 16.3 feet, or 0.3 foot higher than the actual maximum reading. On the diagram is shown by a full line the gauge relation of 1890; that of 1891, shown by a broken line, is about two-tenths lower at Carrollton. An interesting feature of the diagram are the abnormally high readings at all the stations except Carrollton prior to February 16. As this feature shows most prominently at those gauges nearest the "Nita" and other large crevasses of 1890, it seems probable that it was due to deposits caused by those crevasses, which were swept out by the rising river about the date mentioned, lowering the gauge relation to the extent of about half a foot.

Table showing lowering effect of Ames crevasse at different points above and corresponding to the crest of the flood at Bayou Sara, May 1, 1891.

	Distance upstream from crevasse.	Gauges.		Difference.
		Computed height without crevasse.	Actual height.	
Bayou Sara	159.5	38.8	38.8	.0
Baton Rouge	125.7	35.6	35.5	.1
Plaquemine	105.5	31.4	31	.4
Donaldsonville	73.6	28.4	27.5	.9
College Point	56	24	22.7	1.3
Carrollton	2	16.3	14.4	1.9

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Lieut. Col. of Engineers,
Member Mississippi River Commission.

Gen. C. B. COMSTOCK,
President Mississippi River Commission.

APPENDIX 2.

REPORT OF LIEUTENANT-COLONEL CHARLES R. SUTER, CORPS OF ENGINEERS, UPON THE VELOCITY OF FLOOD TRAVEL ON LOWER MISSISSIPPI RIVER.

ST. LOUIS, MO., *June 14, 1892.*

GENERAL: I beg leave to submit herewith, for the information of the Commission, the results of further study of the velocity of flood travel on the Lower Mississippi. This subject was alluded to in the paper submitted by me under date of August 3, 1888 (published as Appendix A to the Annual Report of Commission for 1891), but for lack of time could not then be elaborated as fully as desirable. The conclusions there stated were derived from a comparison of hydrographs, and of discharges simultaneously measured at different points along the river. The determinations of

*Printed in Annual Report, Chief of Engineers, 1891, page 3444.

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velocity of travel were only approximate, but such corrections as are now made are not sufficient to materially affect the other conclusions embodied in the previous paper. In that paper the gauge relations were constructed by using the approximate time intervals determined as stated above; in the present case the intervals are determined from a careful study of the gauge relations themselves. The method used, exceedingly ingenious and interesting, was devised by my assistant, Mr. Seddon, and is fully described in his report to me, a copy of which is appended, and to which reference is made for all details. Briefly stated the method used depends upon the fact that where no tributary increment is received, the readings at a downstream gauge which correspond to those of a gauge upstream should be alike for both rising and falling stages. If they are not, the interval allowed is either too long or too short. By taking trial intervals varying by one-tenth of a day, the smallest fraction that can be reasonably well used in interpolating between the recorded gauge readings, and by studying each rise and fall separately, the interval can be determined to within about a half a tenth a day, or about an hour and a quarter, and this is probably as close an approximation as can well be expected with gauge readings such as are now taken. The sections of river between the main tributaries are taken separately, the uppermost gauge being compared with each of the lower ones in succession. Thus for the section Cairo-Helena, the Cairo gauge is compared successively with those at Belmont, New Madrid, Cottonwood Point, Fulton, Memphis, Mhoons, and Helena. In this way gradually lengthening intervals are obtained, a constant check on the accuracy of the method is furnished, and any tributary effect can be readily determined. As the limit of error in the determination of the interval is a constant one, its percentage of the total will of course vary, and the long intervals are therefore more accurately determined than the shorter ones.

In passing from one basin to another it is necessary to choose such periods as are not complicated by tributary increment. This materially reduces the range of the observations, and the interval can not be considered so well determined as in other cases; still, it is not thought that any material error is incurred. The rates of travel as thus determined are given in Mr. Seddon's paper in tabular form and are also exhibited graphically. The rate from Cairo to Red River Landing is 82 miles per day, instead of 75, as previously assumed, and at intermediate points the rate varies both ways from this mean. Below Red River the rate increases enormously and progressively as we descend the river. But for each reach between gauges the rate is constant from the lowest stages to the highest at which the river may fairly be considered to have adjusted its channel; that is, for all stages short of overflow. This constancy of rate, irrespective of stage, and of the variations in the measured velocity, is very puzzling. Attempts to ascertain the mean velocity at different stages over long stretches of river have been made, and the details will be found in Mr. Seddon's paper. The results, however, still show considerable variation with stage, although these variations are less than in the case of individual sections. The conclusion, therefore, seems unavoidable that some form of transmission similar to wave movement is involved. In the deep river below Red River Landing nothing else will explain the very high rate which is noted, and above that point it seems possible that the deep pools may exert a controlling influence in the same direction, especially at low stages when their influence would be most preponderant. At the higher stages, when their influence would naturally be less, the rate does not vary greatly from the mean velocity between Cairo and Red River Landing. In further support of this view, an examination of the tabulation of local rates (Tabulation I) will show that the highest velocities occur on those portions of the river where deep pools preponderate, and the lowest velocities where the mean depths are a minimum. Premising that in such an examination the absolute depth on the bars between the pools need not be considered, but only the relative length and depth of pools and bars throughout the reach considered, attention is especially called to the reaches Cairo-Belmont, Cottonwood Point-Fulton, Arkansas City-Greenville, and St. Joseph-Natchez, as examples of high velocities combined with a marked preponderance of deep pools, and to the reaches of Memphis-Mhoons and Mhoons-Helena as examples of the converse. An apparent exception to this rule is found in the reach Vicksburg-St. Joseph, which can only be explained by the relative shortness and imperfection of the St. Joseph record, which renders the determination of the local rate at this point somewhat uncertain.

All this evidence seems to indicate that an increase in mean depth will increase the rate of flood travel, and as a rapid and unimpeded discharge of flood waters is the surest guarantee against excessive flood heights, the bearing of these investigations is thought to be of sufficient importance to justify their publication.

Very respectfully, your obedient servant,

Chas. R. Suter,
Lieut. Col. of Engineers,
Member Mississippi River Commission.

Gen. C. B. Comstock,
President Mississippi River Commission.

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REPORT OF MR. JAMES A. SEDDON, ASSISTANT ENGINEER, ON THE MOVEMENT OF FLOODS IN THE LOWER MISSISSIPPI RIVER.

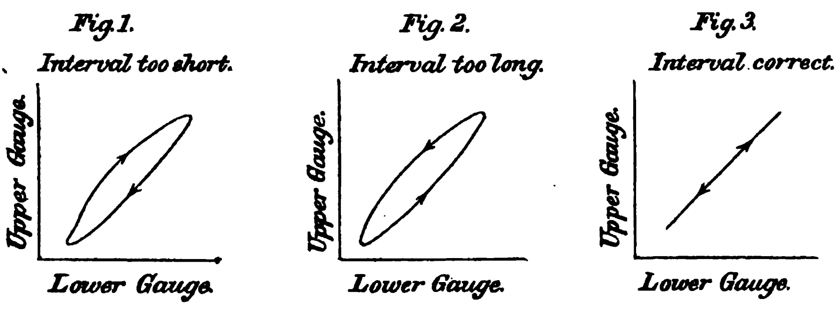
COLONEL: I have the honor to make the following report on the movement of floods in the lower Mississippi.

Up to the bank full stage, or where not complicated by overflow and return flow, and at times when the increments from tributaries are immaterial, it is apparent that a flood wave as given by lower gauge readings is dependent alone on its upper gauge readings and the law of its movement down the river.

It is this law that is sought, and primarily we would see that it might be very complicated, involving changes of shape, dependent on the rates of rise and fall, on different rates of movement at the different stages, and on the existence of reservoir capacity in the river; also the rate of movement might vary, from time to time, and might have different values for floods of different heights.

The great effect of these possible complications is found by platting the gauge relations with constant trial time intervals for successively lengthening reaches. If the relation gives the rise and fall coinciding, or following the same line, when platted with a determined constant interval, it shows that the above complications are then not perceptible in that reach; and by extending to longer and longer reaches we get a measure of the degree of accuracy with which we may say that flood movement is free from them. At the same time, by extending the reach we identify the beginning and growth of the effects of tributary increment, which frees the irregularity below from suggesting a reasonable suspicion of change in the law of flood movement.

These conclusions rest on the following reasoning: Up to the crest on both the rising and falling stages each point in the flood wave at the upper gauge must have its period, after which the same value of discharge, and hence the true equivalent of its gauge height would be found at the lower gauge; now, if in platting a trial gauge relation our assumed time interval were less than the true periods, or too short, then on the rising stage the lower gauge values taken, would not have had time to rise to their true equivalent value, and would be too small in proportion to the rapidity of the rise. In the same way on the falling stage the lower gauge values would not have fallen enough and would be too large in proportion to the rapidity of the fall. The trial relation would therefore plat as in Fig. 1, where the rising and falling stages are indicated by the directions of the arrows.



By the same reasoning we see that if the trial interval had been taken too long the lower gauge values would have been too large on the rising and too small on the falling stages, giving a trial relation like Fig. 2; and if between the trial intervals of Figs. 1 and 2 we find an interval that causes the relation to plat as in Fig. 3, the rising and falling stages coinciding throughout, we must conclude that the flood wave passed down as a whole in this constant time interval, with no perceptible change of shape.

It may be noted here that the position, inclination, and straightness of this line in Fig. 3 in no way affect the above conclusion, nor will these questions be considered in this report, as they form the basis for the independent studies of the relations of discharge curves along the river, and changes in channel efficiency.

Now the degree of accuracy with which this time interval may be determined depends on the rate of rise and fall, and on the accidental errors of the gauge readings; and while the short distance gauge relation in itself might show that there was no phasing of the wave, or change of its interval, perceptible in the short reach, yet it would not follow that these effects, growing with the distance might not be material in the longer reach. But when we extend the reach by keeping the same upper gauge and taking a lower gauge farther down the river, and finding the new interval as before, see the coincidence of the rising and falling stages recurring

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with an equal precision; we have at once a measure of our accidental errors, and the answering argument that divergence does not increase with distance.

By further extending the reach and still finding the flood reproduced in ratio on the lower gauge with the same precision, we are, with a high degree of confidence led to accept as a fact, that the law of flood movement is practically an unphasing movement of the wave as a whole at constant rates from point to point down the river.

The permanence of the interval and its constancy for floods of different heights, is of course determined by extending the investigation to other floods.

Plates I to V present this study of the gauge relations.

Plate I gives the relations in the reach from Cairo to Helena. In this Cairo is uniformly taken as the upper gauge, and the reaches for which the gauge relations are platted are, successively, Cairo to Belmont, Cairo to New Madrid, and so on to finally the reach Cairo to Helena; as in all former gauge relations the dates uniformly refer to the actual time of the upper gauge readings.

Group 1 shows a small flood platted with trial intervals varying by one-tenth of a day, and from this the true interval is easily selected to the nearest tenth. This only leaves a limiting error in the interval of, say, 0.05 of a day, or something over one hour, and it is useless to attempt to reach a greater accuracy than this with the data, on account of accidental errors and probable irregularity in the actual time of reading the gauges. The bending away on November 13, 14, and 15 in the direction of too large gauge readings from Fulton down is an effect of tributary increment and coincidence with the commencement of a rise in the St. Francis River.

Group 2 gives the relations for a higher flood. The Cairo flood is shown exactly reproduced down to Memphis; Helena shows a small tributary increment on the falling stage (at the maximum about 20,000 cubic feet per second). The case of Mhoons deserves a special notice; on January 1 (January 4 at Mhoons) the gauge reader commenced taking the readings on a temporary gauge and continued so to May 23, when he was found to be about 2.2 feet too low. From the gauge relation it is evident that a little over 2 feet of this error was made in the first three days, and the readings might be very safely so corrected. But if this error had been distributed over the whole time, as is often done, it would have given a perfectly incomprehensible condition of the river at Mhoons for about five months.

This instance serves not only to point out the necessity of correcting gauge errors by the gauge relations, if any corrections are to be made, but also the care that must be taken in the study of data already collected in order not to be led into false conclusions from similar cases.

Group 3 gives the relations for a very low rise, and group 4 for the very sharp rise in the fall of 1890. In this last the gauge reading 19.9 Cairo gauge, on the falling stage, is clearly 1 foot in error in its Cairo reading, and has been so corrected and shown as a dotted line.

Plate II gives other groups of gauge relations from Cairo to Helena.

Plate III gives gauge relations from Helena to Vicksburg. In this reach we have the tributary increments from the Arkansas, White, and Yazoo rivers, which prevent a satisfactory study of the intervals through it as a whole.

Group 1 shows a study of the mouth of White River–Arkansas City interval, with various trial times; group 2, a study of the intervals with trial times from Arkansas City to Vicksburg; group 3 another flood from Arkansas City to Vicksburg; and group 4 a study of the intervals from Helena to mouth of White River. In this reach, from Helena to mouth of White River, it is very difficult to find periods in which the movement of floods can be closely studied on account of the large tributary effects.

Plates IV and V give the study for the reaches Vicksburg to Red River Landing and Red River Landing to Carrollton, respectively, and with what has preceded they need no general explanation.

In the Vicksburg–Red River Landing reach the special tendency to change of plane at Red River Landing, considered in former reports, complicates the study of the interval. An instance of this change of plane is shown in group 5, at Red River Landing, between the rising stage of early in November and that of the latter part of December.

In the Red River Landing–Carrollton reach the smallness of the range at College Point and Carrollton make the determination of the interval less accurate. Also there are upstream effects where the interval is reversed, as in the latter part of the falling stage, September-October, 1890 flood, as well as small apparently erratic changes of plane, as that separating the falling and rising stages in the flood of November-December, 1890, all of which add to the difficulties of determining the interval.

But notwithstanding these difficulties, the marked acceleration to the movement of the flood as it passes down the reach is well shown; and there is little doubt but that the old interval used, of one day from Red River Landing to Carrollton, if

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anything out, was too long, though correct to the nearest quarter of a day, which was as close a determination of the interval as was then attempted.

Inspection of these plates can leave no doubt that flood movement in the lower Mississippi River up to the bank full stage follows this very simple law. Every point in any flood wave moves down at the same rate, being found with its same value of discharge at all gauges below after given constant intervals of time; excepting, of course, that these values of discharge may be increased from point to point by tributary increments. Or to state this briefly, we may say, that flood waves in the main river are in a permanent phase.

It should be stated, however, that there are some instances which make it still a question whether the extreme front of a rise, as well as a small hollow in a double rise, are always in a permanent phase; an instance of the double rise is seen on Plate II, Group 1, early in November, 1888. These are points where we know that changes of plane generally occur, and here also interpolations between daily gauge readings are especially subject to error, which with tributary increments may serve to account for the conditions sometimes found. But for the present these must be made possible exceptions to the former general law.

In stating the above as a law of flood movement it may be well to call attention to the fact that while the true interval is determined to a certain degree of precision, and is, therefore, subject to a probable error, the determination of this as the law of movement stands on another footing. Variations from it are altogether imperceptible, and this, though we may test it at times through seven gauges from Cairo to Helena, covering 306.5 miles of river, we must, therefore, accept it as a positive law until some clear evidence of divergence from it is found.

The principal influences that at first would cause us not to suspect so simple a law of flood movement have been already mentioned. It is well, however, to consider them in more detail, with the effects they would have on the gauge relations if operative.

First, the existence of reservoir capacity in the channel. This has never been considered more than a possibility below the bank full stage, though very apparent above it. Its effect would be to decrease volume and stage on the rising river and increase them on the falling, each in proportion to the rapidity of the change of stage and the distance between gauges. The interval for a slow rise or fall would thus appear too short for a fast rise or fall, and this discrepancy would increase with distance.

Second, the plus or minus changes of normal slope caused by the rapidly rising or falling river, causing the velocities and movement of the front of the wave to be accelerated and of the rear to be retarded. This change is by no means insignificant in amount. There are times when the slope between gauges may have a difference of some 15 per cent from this cause, or by the slope formula a difference in the velocities of about 8 per cent. Also the differences in observed mean velocities between the rising and falling stages is a well-known feature of discharge observations.

Such an influence, it would be thought, should perceptibly lengthen and change the shape of the wave, while causing both the rapidly rising and the rapidly falling portions to diverge toward larger lower-gauge values than the normal; the rising stage, because the travel is faster than the assumed interval, and hence the equivalent taken is greater; the falling, because the travel is slower and the equivalent taken has not fallen sufficiently; or all rapid changes of stage would indicate an excess of lower-gauge equivalent when compared with slower or stationary periods, which excess would increase with the distance between gauges.

But the cause which more than all others would at first lead us not to expect so simple a law of flood movement is the fact that the mean velocity of the river increases as the river rises. This is a well-known feature of all discharge stations. An instance of it is shown on Plate VI, where the mean velocities of the Fulton observations in 1880 are plotted to their respective gauge readings. This, however, only gives the range of mean velocity in a selected section, and it is apparent that in some of the wide sections the range must be much smaller and may in some instances even be negative. To value the range of these aggregate mean velocities it is necessary to determine the mean velocity of a long reach at different stages, or $\frac{V}{R}$. This for a stationary river is simply discharge divided by mean water area of the reach; or

$$\frac{V}{R} = \frac{Q\ L}{\text{Vol.}} \left\{ \begin{array}{l} \text{where Q equals the discharge, L the length,} \\ \text{and Vol. the water volume of the reach.} \end{array} \right.$$

The 1879 survey of the Plum Point Reach offers a good opportunity for determining this range in the value of $\frac{V}{R}$. This reach has a length of 38.7 miles, commencing from about 6.6 miles above Ashport and extending down to about 2.7 miles below

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Randolph. In this survey two periods of about a stationary river were selected, the first, March 28-31, 1879, with a stage of 25.4 on the Fulton gauge; the second, June 15-22, 1879, with a stage of 12.2. In or close to each of these periods the sections had been sounded, and the series of discharge observations taken above at Columbus and below at Memphis showed that the discharge during these periods was uniform along the whole reach and gave accurately its value for each period.

From these data the mean velocity of the reach of the two stages was determined, and their values are shown plotted to their Fulton gauge heights on Plate VI. The straight line through these points is taken as giving the total range in the mean velocity of the Plum Point Reach, since on the Lower Mississippi, in general, the variation of mean velocity with gauge height has been found to be satisfactorily expressed by a straight line.

The high and low water areas for each section in this Plum Point Reach, with their corresponding mean velocities are also shown on Plate VI as longitudinal variations.

The range in mean velocity of the reach is seen to be much less than that of the Fulton section, as was expected; but it still has a considerable range from about 3.1 feet per second at low water to about 5.1 at the bank-full stage, and from the nature of the reach it is probable that this is about as small a range as would be found in any long reach on the Lower Mississippi.

With such a range it is perfectly apparent that, if each point of the flood was moving down with the mean velocity of its stage, any such relation between gauge readings as is found would be impossible; small floods at low water would have an interval nearly twice as long as at high water, and, omitting the changes of shape, which would be large, the best trial interval that could be obtained for floods of any considerable range would be one showing an interval too short at the low stages and too long at the high stages.

We are brought therefore to the fact that these floods, at least from Cairo down, have a travel that, whether made up of complex properties or no, actually corresponds to a plane-wave movement.

Whether this is a true wave movement, that is, does pressure acting through the mass cause a travel by transmission; or whether the phenomena may be accomplished by simple flow or translation alone, requires further consideration. To define these questions more specifically we may say that, in translation all pressures acting through the mass are considered as expended simply in the acceleration of velocities of flow, or in a normal slope effect; while in transmission we consider that an element of the pressure may cause a vertical motion which changes the form of the free surface, as in the movement of a plane wave.

It may be stated at the outset that from Baton Rouge down the travel is unquestionably one of transmission, for not only does it clearly exceed the known bounds of possible translation, but it lies very fairly within the range of tide movements up an estuary, which are known to be cases of transmission. (See Coast Survey Report for 1881, page 469, for movement of tides up the Delaware River.)

Also above Baton Rouge, as at low water the pools present much the same features that hold below, we might naturally infer that the travel across them at the lower stages is also a transmission; but before forming an opinion on this subject it will be necessary to consider briefly the limits of translation or the relation of the travel of discharge to the velocities of flow where no pressure or transmission is acting.

Before a definite relation of the travel of discharge with velocities of flow can be reached it is necessary to make a definite assumption in regard to the conditions of flow; and as one extreme we will first assume that the individual masses of water retain permanently their same relative velocities in the cross sections; that is, the mass that has maximum velocity in one section when it reaches any section below still has the maximum velocity of that section, and so on through all the range of velocities to the minimum.

This is called "perfect flow," and it is seen that this a condition in which the actual particles of water, forming the discharge at one place, are separated to their greatest possible extent in their movement down the river, and it may be shown that in this movement down the discharge of a changing stage is constantly tending towards a movement with the mean of the maximum velocities of the river.

As the opposite of this condition of flow we have the condition of "perfect circulation," or where the individual masses of water pass in turn through all the velocities of the river in such a way that, in the aggregate, they are only temporarily separated during the period of a cycle.

In this as the actual particles forming a discharge in one place are, as a whole, held together in their motion down the river, it is apparent that the travel of discharge is with the combined mean velocities; or with $\frac{V}{R}$ the mean velocity of the reach.

Between these two extremes must be found all actual conditions of flow in the river, and the travel of discharge consequently may vary from mean towards maxi-

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mum velocity as we pass from "perfect circulation" to the condition of perfect flow. It should be remembered, however, that from all observation, as well as from theoretical conceptions, we know that perfect flow of water is physically impossible, except, perhaps, for very slow motions in smooth pipes. On the other hand, besides the knowledge that circulation is a prominent feature of river flow, we have in the study of sediment between St. Charles on the Missouri, and Columbus, Ky., on the Lower Mississippi, the suggestion that it is at least close to perfect circulation. (See Report Chief of Engineers, 1887, page 3092, which is found the only data collected that bears directly on this question.) So that from the above we may only conclude that possibly the travel of discharge may have some variation from mean toward maximum velocity.

If this were accepted and further assumption made that circulation was far from complete at the low stages and approached completion at the higher stages in such a way as to give the uniform rate of travel found, the actual movement of floods would then be explained without the assumption of a partial transmission.

On the other hand we have the unquestionable fact that transmission acts below Baton Rouge and the strong inference that it would act in the same way across the pools at low water to accelerate there the travel of discharge, which might also fairly cause the uniform rate of travel found.

Between these two explanations we can not as yet say whether the one or the other or both combined cause the simple law found for flood movements, but it is thought the weight of evidence is decidedly in favor of the latter, or that there is in part a transmission or true wave movement acting in the travel of these floods from Cairo down, which becomes altogether the controlling element below Baton Rouge, and this notwithstanding the fact that they are often so long that the lower end of the front phase is in the gulf while the crest is still falling as rain in the basins of the upper tributaries.

Tabulation I gives the intervals and rates of travel of floods as determined by this study. The "full reaches" show the limiting distances through which floods were progressively studied on account of the interference of tributary increments.

In using the printed gauge records it may be noted that the difference in time between the Benyaurd gauge readings at 8 a. m. and the Commission gauge readings, with a mean time of 12 m., must be allowed for the intervals prior to February 1, 1887.

TABULATION I.

	Gauges.	Distance from Cairo.	Interval from Cairo.	Distance between gauges.	Interval between gauges.	Travel of floods between gauges.
		Miles.	*Days.*	*Miles.*	*Days.*	*Miles per day.*
	Cairo	0.0	0.0	......	......	......
	Belmont (Columbus)	21.3	0.1	21.3	0.1	213.0
	New Madrid	70.8	0.6	49.5	0.5	99.0
Full reach	Cottonwood Point	123.3	1.3	52.5	0.7	75.0
	Fulton	175.4	1.7	52.1	0.4	130.2
	Memphis	230.0	2.3	54.6	0.6	91.0
	Mhoons	275.9	3.0	45.9	0.7	65.6
Do	Helena	306.5	3.5	30.6	0.5	61.2
Do	Mouth White River	393.2	4.6	86.7	1.1	78.8
	Arkansas City	438.3	5.1	45.1	0.5	90.2
Do	Greenville	478.5	5.4	40.2	0.3	134.0
	Lake Providence	542.3	6.3	63.8	0.9	70.9
	Vicksburg	599.3	7.1	57.0	0.8	71.3
Do	St. Joseph	648.3	7.9	49.0	0.8	61.3
	Natchez	700.3	8.4	52.0	0.5	104.0
	Red River Landing	765.3	9.3	65.0	0.9	72.2
	Bayou Sara	799.5	9.6	34.2	0.3	114.0
	Baton Rouge	833.3	9.9	33.8	0.3	112.7
Do	Plaquemine	853.5	10.0	20.2	0.1	202.0
	College Point	903.0	10.1	49.5	0.1	495.0
	Carrollton	957.0	10.2	54.0	0.1	540.0

It is seen by the last column in the tabulation, or travel in miles per day, that besides the marked increase in the rate of travel below Red River Landing, before noted, there is also a decided irregularity in the different parts of the river. It must be remembered that this irregularity above Red River Landing may have been materially exaggerated in the short distances between gauges by the limits of accuracy to which the interval was determined and by possible differences in the actual time of reading the gauges. But allowing for this, there still remains no doubt that

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there are distinct differences in the rates of travel through different reaches down to Red River Landing. These differences in the travel have as yet not been connected with any physical cause, and beyond the supposition that they depend in some way on the relative lengths of pools and bars, possibly combined with slope and mean depth, there is no explanation for them.

The curve of interval to distance from Cairo is shown plotted on Pl. VII, and presents more clearly to the eye these irregularities of travel. On this plate, following out the original assumption that the interval was determined to within ± 0.05 of a day, dotted lines have been drawn above and below the curve, diverging by this amount for each full reach. They represent on this assumption the extreme possible error of the total interval from Cairo down to any point. The possible error of interval between intermediate points is of course less, and can easily be made up by this allowance of ± 0.05 of a day for each full reach, or any part of a full reach; for while ± 0.05 is taken as the limiting error, say, from Cairo to Helena, it is also taken as the error from Cairo to New Madrid, or any other part of this Cairo-Helena reach, which was studied as a whole.

The limiting gauges to the full reaches are marked with an asterisk on Pl. VII; also on the plate the curves of limiting error have not been extended below Red River Landing since, as before considered, the determinations of the intervals there may not be so exact.

In the annual report of the Mississippi River Commission for 1890 there is a tabulation giving in long reaches the mean water area from Cairo down for the bank full stage. (See Report of Chief of Engineers, 1890, page 3129.)

From this, by taking the discharge for this stage as 1,000,000 cubic feet per second, we may determine approximately the mean velocity of these reaches, or $\frac{V}{R}$ for the bank full stage from Cairo to Carrollton. This is given in Tabulation II, in comparison with the velocity of flood travel for the same reaches, deduced from the time intervals.

TABULATION II.

Reaches between the following gauges.	Length of reaches.	Time intervals of reaches.	Travel of floods from time intervals.		Mean velocity of the bank-full stage.
	Miles.	*Days.*	*Miles per day.*	*Feet per second.*	*Feet per second.*
Cairo	0.0	0.0			
New Madrid	70.8	0.6	118.0	7.20	4.67
(Plum Point.)					
Fulton *	104.6	1.1	95.1	5.80	4.74
Memphis	54.6	0.6	91.0	5.55	5.00
Helena	76.5	1.2	63.7	3.88	5.10
(Arkansas River.)					
Arkansas City *	131.8	1.6	82.3	5.03	5.24
Greenville	40.2	0.3	134.0	8.17	5.08
Lake Providence	63.8	0.9	70.9	4.33	5.02
Vicksburg	57.0	0.8	71.2	4.34	5.13
Natchez	101.0	1.3	77.8	4.74	4.93
Red River Landing	65.0	0.9	72.2	4.40	4.72
Baton Rouge	68.0	0.6	113.3	6.91	5.00
Carrollton	123.7	0.3	412.3	25.15	5.43

* The reaches in the Commission's report. New Madrid to Plum Point and Helena to Arkansas River, are respectively taken as New Madrid to Fulton and Helena to Arkansas City to correspond with reaches for which the intervals have been determined.

If the deduced mean velocities of the reaches are to be relied on, there seems to be no definite connection between this and the flood travel; and beyond the further evidence that the travel of floods below Baton Rouge is altogether out of the range of a velocity movement, there is little to be gained from this comparison.

It should, however, be stated that while there are marked differences in the reaches, the mean values down to Red River Landing of the flood travel and of the mean velocity are very close together; the mean flood travel being 5.03 and the mean of the mean velocities at the bank-full stage being 4.96 per second.

It is thought that this may be simply a coincidence, or it may point to a general tendency towards flood travel above Red River Landing as an average being developed, so as to have the general mean velocity of the bank-full stage. This might either mean perfect circulation at stages whose averages for the whole river correspond to the mean velocity of the bank-full stage, or might as well mean the disappearance of the transmission element of the flood's motion at these stages.

But whatever uncertainty there may be in the theoretical consideration of the causes of this law of flood movement, I think we may safely say that there is in hy-

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draulics no law which more accurately expresses so broad a generalization of observed facts and whose field of application gives so great a promise in the study of the flow of water in natural channels.

Very respectfully, your obedient servant,

JAMES A. SEDDON.
Assistant Engineer.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

APPENDIX 3.

REPORT OF CAPTAIN S. W. ROESSLER, CORPS OF ENGINEERS, UPON SURVEY OF NONCONNAH ROCKS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., May 24, 1892.

SIR: I have the honor to submit herewith the map of a survey of Nonconnah Rocks made pursuant to a resolution of the Commission dated November 18, 1890. The survey included soundings in the vicinity of the rock, examination by a submarine diver and the obtaining of specimens of the stone.

The rock is located about 5 miles below the city of Memphis, opposite and above the mouth of Nonconnah Creek, and is about 700 feet out from the Tennessee shore and 2,000 feet from Presidents Island shore.

A previous examination of the rock was made by Capt. Leach, September 19 and 20, 1889, and a report made by him under date of December 13, 1889. At that time the main channel was between the rock and Presidents Island, and a narrow channel, rarely used, existed between the rock and the Tennessee shore. Around the rock and partly covering it was a large flat gravel bar, sloping upwards toward the rock where the general level of the bottom was about 1 foot below the water surface, corresponding to zero on the Memphis gauge. Since that survey the channel has moved from Presidents Island to the Tennessee shore and there has been a deep scour in the gravel bar in the vicinity of the rock, on all sides of it, and in the channel between it and the Tennessee shore. About 150 feet east of the rock the scour was about 27 feet, and 200 feet farther in the same direction, 16 feet; 200 feet above the rock, 10 feet; 350 feet west of the rock toward Presidents Island shore, 4 feet, and in the immediate vicinity of the rock, the scour varied 17 to 27 feet. The rock itself shows the effect of erosion in the interval, the height at the last survey (2.80 above zero stage) being 3 feet below that indicated by the survey of 1889.

The section of the rock by a horizontal plane 8 feet below zero stage has approximately the shape of an ellipse with longer and shorter diameters respectively 190 and 130 feet. Above this section, the shape of the rock, as well as can be inferred from the soundings taken, is something like an oblique frustum of a cone with a steep slant on its east side and a flat slope on the opposite side toward Presidents Island, and contains approximately 3,000 cubic yards.

Since the change in the position of the channel to the Tennessee shore, the rock has become a more serious obstruction to navigation than it had been theretofore, and its removal made more urgent.

It is difficult to estimate the cost of excavating it. The material is a soft, ferruginous sandstone or pudding stone easily broken up and pulverized under a hammer, which would be pulverized to a large extent by blasting and washed away by the current. A large part of the highest projection at the eastern end of the ledge can also be blasted off into deep water, thus reducing materially the amount that would have to be dredged up and towed away.

In the absence of any similar work as basis for an estimate, I place the cost at $2 per cubic yard, or $6,000 for excavating the rock to a depth of 8 feet below zero stage. The method of removal proposed is to do the work at low water, to break the rock by surface blasting, to proportion the size of blasts so as to pulverize the rock as much as possible and remove by dredging the coarser material which the current will not move.

It is proper to add that the difference between my estimate and Capt. Leach's of the quantity of rock to be removed, mine being less than one-half of his, is due to the fact that a larger part of the rock at the time of his examination was covered by the gravel bar, a portion of which, since scoured away, was probably included in his estimate as rock.

Very respectfully, your obedient servant,

S. W. ROESSLER,
Captain of Engineers.

Gen. C. B. COMSTOCK,
President Mississippi River Commission.

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APPENDIX 4.

REPORT OF CAPTAIN CARL F. PALFREY, CORPS OF ENGINEERS, SECRETARY MISSISSIPPI RIVER COMMISSION.

UNITED STATES ENGINEER OFFICE,
St. Louis, Mo., May 31, 1892.

GENERAL: I have the honor to present the following report of operations under my charge as secretary Mississippi River Commission and assistant to construction committee from July 1, 1891, to May 31, 1892.

These works are carried on under the following allotments from the appropriations approved September 19, 1890, and March 3, 1891, made by the Commission and approved by the honorable the Secretary of War:

First. "Mississippi River Commission," applicable to salaries of three Commissioners, to expenses of offices of president and secretary, and to expenses of meetings and inspections of Commission.

Second. "Surveys, gauges, and observations," applicable to the general survey of the river, to collection and office reduction of physical data, and to general examinations and computations not confined to any one district.

Third. "General service," applicable to supply of stone, maintenance of plant, and general aid to works in the districts.

The small balances from earlier appropriations which appear in the financial statement are set off by outstanding liabilities for telegrams, which can not, under existing orders, be adjusted.

MISSISSIPPI RIVER COMMISSION.

The Commission has held three sessions during the period reported, at New York City, July 15-17, 1891; from St. Louis to New Orleans, November 5-18, 1891; from St. Louis to New Orleans, May 4-10, 1892.

SURVEYS, GAUGES, AND OBSERVATIONS.

Secondary triangulation.—On July 1, 1891, a party, in the field since April 25, under Assistant Engineer Charles W. Stewart, with Assistant Engineers F. B. Maltby, A. T. Morrow, and George H. French, under his orders, had carried their work 4 miles above Burlington, Iowa, having then covered about 50 miles of river, occupied 31 stations, marked 34 triangulation points, and 19 stone lines. This party completed its field work on July 28, at Port Louisa, Iowa, covering during the season about 85 miles of river. Reconnoissance had been made for more triangulation, but the progress of this work was slower than had been anticipated, owing in part to hazy weather, and in part to the great number of stations found necessary in the narrower parts of the valley. From Keokuk to Lomax, a distance of 36 miles, there were 25 triangles, sides averaging 2.3 miles; from Lomax to Port Louisa, a distance of 49 miles, there were 13 triangles, sides averaging 7.3 miles; 24 stone lines, Nos. 112 to 135, inclusive, have been marked by 81 tile and pipe monuments. A base line nearly 3¼ miles long was measured along the railroad track near New Boston, Ill.; observations for azimuth made at "West Base." At the close of the field work, Assistant Engineer Stewart returned to the office for computation and reduction of the triangulation; the instructions for this work are given in Annual Report for 1891, pages 3474-3476.

The chain consists of 49 triangles, extending from base line measured at Keokuk in 1881 to base line at New Boston; its length along its axis is about 78 miles. The greatest error in closing any triangles is 05″.03; the least, 00″.08; the mean of all 02″.33.

The base line was measured in two sections. The first section, about 2,500 meters, was measured east and west in good weather; discrepancy of two measurements, 1:575,346. The second section was measured east and west, the sun coming out during measurement east; discrepancy, 1:171,390. A second measurement east was taken, giving with measurement west a discrepancy of 1:4,063,050. These results were accepted. The measured length of base line is 5,506 meters; the length, computed from base at Keokuk, is 5,506.2576 meters; discrepancy, 1:21,374. The observed azimuth of base is 253° 18′ 49″.06; the azimuth computed from Keokuk base is 253° 18′ 48″.48; discrepancy, 00″.58.

The location of stone-line monument has been determined by direct observation from triangulation stations with triangulation instruments, or by short lines of connection run with Gambey transit reading to 5″. The error of position is well within the possibility of delineation on a scale 1:10,000.

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Detailed report of this work by Assistant Engineer Stewart, with tabulated results, is appended (marked A).

On March 28, 1892, Assistant Engineers Stewart and French took the field near Muscatine, Iowa, for reconnoissance and location of triangulation stations from Port Louisa, Iowa, northward. This reconnoissance was carried to Dubuque, Iowa, and base lines selected near Rock Island and Dubuque.

The full party, consisting of Assistant Engineer Stewart, in charge, Assistant Engineers Morrow and French, Recorders C. L. Ockerson, O. N. Axtell, and M. I. Powers, and crew and working party, consisting of T. C. Hockridge, master and foreman, and twenty-three men, assembled on board steamer *Patrol* at New Boston, Ill., on April 25, and began work at Port Louisa, Iowa, on April 26.

On May 31, this party had reached Fairport, Iowa, having occupied 16 triangulation stations, marked 18 triangulation points and 12 stone lines, the completed work covering about 22 miles of river. It has rained on 27 days in May.

Precise levels.—On July 1, 1891, a double precise-level party, under Assistant Engineer O. W. Ferguson with Assistant Engineer A. L. Johnson, working from St. Paul to Savanna, Ill. (in the field since April 25), was at Alma, Wis., having run 95 miles by river, and placed 48 permanent bench marks; a single precise-level party under Assistant Engineer James A. Paige, working from Duluth to St. Paul (in the field since April 26), was near Willow River, Minn., having run 54 miles and placed 12 permanent bench marks.

The field work of the line from St. Paul to Savanna was completed October 20, connecting with work of 1883 at three bench marks. The length of this line is 301.2 miles; 379 permanent bench marks were placed; 106 of tile and pipe; 57 of copper bolts; 216 cut in rock in situ or on trees; 49 bench marks of former United States Engineer surveys were connected and also 12 gauges and 7 city bench marks.

The line of this party was in general over favorable ground. About 84 per cent was on railroads; about 16 per cent along river; there were six river crossings.

The party was quartered and subsisted on quarter boat *Kentucky*, moving downstream by aid of the current, and never far from the work.

The field work of the line from Duluth to St. Paul was completed on September 28. Connection was made on September 26 with bench marks 68, 69, and 71 of the St. Paul-Savanna line; about 3 miles of the line was rerun after this connection. The length of this line is 156.2 miles. Forty-two permanent bench marks were placed; 32 of tile and pipe; 10 cut in rock in situ or on trees. Three engineer bench marks at Duluth and the engineer gauge there were connected.

The line of this party was over ground less favorable than that of the other. About 12½ per cent was on wagon roads, rough, and with abrupt changes of line, the remainder on railroad track. Departures from the railroad to save length of line proved disadvantageous. The rerunning of 3 miles was owing to one of these.

The party was furnished with wagon transportation but not with camp outfit, depending for lodging and subsistence upon villages and farm houses. In thinly-settled parts of the line this caused an important loss of time. Even in well-settled districts, the hours at which work of this kind is best done made it desirable that the serving of meals be under the full control of the chief of party.

The preliminary instructions for this work are given in Annual Report for 1891, pages 3476–3480. Instructions changing the order of reading the rods were, by direction of the president Mississippi River Commission, given after work had begun. They were repeated in the subreports.

The chiefs of party made each the reduction of his own line. The results are as follows:

	mm.
St. Paul-Savanna, 301.2 miles:	
Probable error of final bench	13.77
Probable error per kilometer	0.625
Duluth-St. Paul, 156.2 miles:	
Probable error of final bench	15.7
Probable error per kilometer	0.99

Detailed reports, with tabulated results, and descriptions of bench marks are appended as follows: St. Paul-Savanna line, by Assistant Engineer Ferguson, (marked "B"). Duluth-St. Paul line, by Assistant Engineer Paige (marked "C").

Topography and hydrography.—On August 4, a party under Assistant Engineer F. B. Maltby, with Assistant Engineers A T. Morrow (on tertiary triangulation and stone-lines), W. G. Comber, G. H. French, O. W. Connet, E. J. Thomas, and H. Dunnaway (on topography), E. L. Harman (on hydrography and later on topography), and recorders L. D. Cabanné, O. N. Axtell, C. L. Ockerson, and M. I. Powers, with T. C. Hockridge, master of boat (later on hydrography) and crew and working party of one pilot, one engineer, and forty to forty-five men, began work at Stone-line 61, near Alton, the close of work of 1889. Their work for the season was closed at Stone-

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line 94, near railway bridge at Hannibal, Mo., a distance of about 118 miles by river. Outside the limits of detailed work, bluff-lines were located on right bank from St. Charles to Clarksville, Mo., about 50 miles, on left bank near Hamburg Bay, about 40 miles, and along both banks of Illinois River for about 10 miles; also water courses and lakes between the belt of detailed work and the bluffs. The stage of the river was exceptionally low, and very full detail of bars and islands was obtained. Very little field-work time was lost by rain.

The party was quartered and subsisted on steamer *Patrol* and quarter boat *Illinois*, kept as nearly abreast of the work as practicable.

The instructions for this work are given in Annual Report for 1891, pages 3481–3485.

The tertiary triangulation occupied 236 stations, and closed on three measured bases and seven sides of secondary triangulation; average error of closing, 1:4870. Thirty-three stone-lines were marked.

The stadia lines, aggregating about 325 miles, were checked by 165 closings upon determined points, and by 115 azimuths; average error of length at closing, 1:875, of azimuth, 02′.4.

Lines of ordinary levels on both banks, with crossings near each stone-line, checked each other with a greatest discrepancy of 0.203 feet, average of 0.101 feet. These lines were checked at 22 points upon lines of precise levels run in 1880–'81, with discrepancies ranging from +0.147 to —0.135. Seventeen high-water marks of dates from 1851 to 1888, whose history and accuracy appeared well established, were connected.

Soundings were taken on 853 sections, also in continuous line where channel was evident, and in several trial lines over shallows and divided channels. These lines were useful to pilots during low water, developing in some cases better channels than those in use, and in one revealing an important obstruction, which was buoyed and reported to the light-house inspector.

Field platting was little done except the closing of instrumental lines; the field notes are full and carefully kept.

Detailed report of Assistant Engineer Maltby is appended (marked D).

Caving banks and stone-lines.—In accordance with resolutions of the Commission, of November 19 and 24, 1891, and March 22, 1892, a party was sent out to examine the condition of permanent marks of the Commission's surveys below Cairo and to determine the amount of caving since the original surveys, the interval varying for different parts of the river, being, on the average, about 10 years.

The party, consisting of Assistant Engineer F. B. Maltby, in charge, with Messrs. French, Thomas, Hockridge, and Ockerson, left St. Louis on the *Patrol*, on November 17, and began work at Cairo on November 20.

On January 1, 1892, at 6 a. m., the *Patrol*, moored against the left bank near Commerce, Miss., was struck by a sudden and severe storm. Her stern line parted, and she swung out into the stream. The action of wind and current careened her till the lee side of boiler deck was under water, and she sank with bow against the bank, and stern in 13 feet of water. The pilot and working crew on main deck were up; the survey party on boiler deck were still in bed, and escaped with much difficulty and little clothing, in a temperature below freezing. One of the deck crew, Parke Driscoll, was lost; the body not recovered. All of the deck crew lost clothing and other personal effects. The boilers were displaced by the shock, and stoves and heavy furniture thrown down. The instruments and records were saved with no material injury.

The steamer *Pete Kirns* was supplied in place of the *Patrol* by the officers in charge of the first and second districts. The party was transferred to her and work was resumed on January 8. Assistant Engineer Maltby resigned charge of the party, and Assistant Engineer A. T. Morrow relieved him on January 16. In his hands the work was carried on, reaching Donaldsonville, La., on March 22. Here about half of the party was discharged. On the return trip certain bench marks which had been covered by snow when passed in the survey were searched for, and new descriptions of bench marks were prepared where needed.

The nature of this work did not admit of detailed instructions. For the balance of his two works, and as a reasonable time-limit on the search for marks, the chief was directed to push his bank-line survey so as to complete it in one low-water season; not to delay his whole party for the marks of any stone-line after two had been recovered, and not to delay more than a day for any stone-line if the one before it was fully established. Some gaps in the series, left under this instruction, were filled on the return trip.

Sheets of tracing linen with protractors printed on them were supplied. The projection and permanent marks connected with, were traced on these from the charts, scale 1:20000, and the shore line platted on same scale. These plats were sent in at intervals of ten days, or when mail communication was had. The results were transferred at once in the office to the 1:20000 charts and reduced on the inch-mile maps. The caved areas were shaded with lead pencil, the levee lines as received from the

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district officers and levee engineers platted, the sheets paraffined till fairly transparent, and blue-print copies made. By this means, with some days lost for want of sunlight, fifteen copies of the entire series (26 maps) were completed on April 11.

Of 1,460 permanent marks searched for. 635 were found and remarked where necessary; 180 are known to have caved into the river; 37 to have been dug up; 32 to have been broken or otherwise destroyed; 127 to have been covered by levees, or by sedimentary deposit beyond hope of recovery without great expenditure of time and labor.

Many of the earlier marks were even with the ground surface, and were not well indicated by blazes or other guide marks. It is very possible that a sufficient expenditure of time, should the need of them justify it, may recover more of them.

Of the marks which have been dug up, many appear to have been disturbed ignorantly in clearing the ground, and were found lying near their places, but not accurately replaceable by their descriptions.

It is noteworthy that the levee engineers have paid little respect to the bench marks of the Commission. Marks have been buried in enlargement or building of levees with no note of them, and have been dug up in obtaining the earth supply with no apparent attempt to protect them.

Of the triangulation marks, about one-quarter were found; these were of various characters, some not durable, and many near the river.

Of the precise level marks, a little over one-half were found; these in this section were generally near the river.

Of the stone-line marks, over two-thirds were found; those near the river are in many lines lost by caving. No line is entirely lost, and most have still two or more marks.

This examination shows that a buried stone or tile with iron pipe extending well above ground has made the most permanent and recoverable mark; that sills and marks in masonry are valuable only when placed in buildings of permanent importance; that levees and their immediate neighborhood are unfavorable locations; and that public roads and property boundaries are by far the most favorable locations.

Report of Assistant Engineer Morrow is appended (marked E).

A study of areas of land lost, and probable volume of earth swept into the river, has been made by Assistant Engineer Ockerson. His results are appended (marked F).

The field work of surveys has been continuous since April, 1891, or, including reconnaissance, since March, 1891.

The triangulation work closed at Fort Louisa on July 28. The same day the steamer *Patrol* and quarter boat *Illinois* started down the river. On the morning of July 31 the quarter boat was left at Hop Hollow, near Alton, and a part of the force began looking up permanent marks for the topographical work. The *Patrol* reached St. Louis on August 1, coaled on 2d (Sunday), and left on 3d. Topographical work began with full force on August 4. This work closed at Hannibal on November 13. The *Patrol* reached St. Louis on November 15 and left on November 17, with Caving Bank and Stone-line party. This party returned on April 12. The repairs of *Patrol* were completed at Cairo on April 18; she arrived at St. Louis April 20, her boilers were tested on April 23, and left on triangulation work on same day. The reconnaissance party, in the field since March 28, joined at New Boston and work began on April 25. The personnel of these parties was transferred from work to work as the same progressed. The precise level parties, independent in organization, were, in addition to these, in the field up to September 28 and October 20.

The topographical party got out of the upper river less than a week before the first closing of the ice lowered the water. The Caving Bank party finished their work before the sloughs were full, and made their return trip on a rising river. The triangulation party reached their field before the rise of the Upper Mississippi became important.

All parties were inspected one or more times in the field.

Manuscript charts, etc.—On July 1, 1891, detail charts, scale 1:10000, were completed, except titles and notes, as far as the southern boundary of the city of St. Louis, with two sheets extending to Alton, projected and outlined.

They are now completed, except titles and notes and mechanical printing of topographical signs, to include No. 121, extending to stone line 74, 3 miles above Cap au Gris. Nos. 122-3-4, extending to midway between stone lines 85 and 86, are in progress.

In connection with them the sounding plat, serving also as index sheet for charts in progress, is completed to stone line 88; the field plats are traced to stone line 82.

Sheets 1 and 2, index charts, for charts on scale 1:20000, have been prepared.

A plat of the triangulation of 1891 has been made. Copy is herewith presented (with Assistant Engineer Stewart's report).

The office force for this work consists of the field topographers. All surveys and mapping have been under supervision of Assistant Engineer Ockerson.

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On July 1, 1891, topographical maps, scale 1 inch: 1 mile, were completed to 6 miles above Chester, Ill. (126 miles above Cairo), with one sheet extending to 148 miles above Cairo in progress. They are now completed to Waterworks, St. Louis (195 miles above Cairo), with one sheet extending to mouth of Missouri River (207 miles above Cairo) in progress.

This work is in the hands of Mr. C. W. Clark.

Published charts and maps.—The charts and maps published by the Commission are the following; except official issues under resolution of the Commission, they are, in accordance with law, sold at the prices annexed. The publication of the first is completed; that of the others is in progress:

		Cents.
Alluvial Valley (scale, 1 inch: 5 miles)	per sheet..	10
Alluvial Valley (scale, 1 inch: 5 miles)	per set (8 sheets)..	40
Mississippi River (scale, 1: 20000)	per sheet..	20
Mississippi River (scale, 1 inch: 1 mile)	do....	5

On July 1, 1891, of the charts, scale 1: 20000, sixty-six sheets, extending from Cairo to Donaldsonville, La. (numbered southward from 3 to 69), and three sheets, extending from Cairo nearly to Cape Girardeau (numbered northward from 101 to 103), were published; six sheets, extending to Chester, Ill., were in the hands of the printer.

The southward series has not been extended. Of the northward series, fourteen sheets (Nos. 101–114), extending 2 miles above stone line 50, or nearly to southern limit of Carondelet, are now published.

On July 1, 1891, of the inch: mile maps, the series from Cairo southward in thirty-two sheets (numbered southward 1 to 32), with index chart (three sheets), and table of distances (one sheet), was complete. Of the series from Cairo northward, five sheets (numbered 101 to 105), extending to 148 miles above Cairo, are in hands of the printer; unsatisfactory proofs have been received.

There have been issued, July 1, 1891–May 31, 1892—

	Free.	Sale.	Total.
Alluvial Valley	113	146	259
Scale 1: 20000	2,359	171	2,530
Scale 1 inch: 1 mile	928	440	1,368

Proceeds of sale, $61.60, have been deposited with the assistant treasurer of the United States at St. Louis.

Physical data.—Records of gauges under the Commission, as also of certain others under Majs. Mackenzie and Miller and Capts. Willard and Taber, Corps of Engineers, under the Weather Bureau, and the Cincinnati waterworks, have been received, tabulated, and printed in pamphlet form, together with descriptions of gauges and bench marks revised to date. Results are appended (marked G).

Computation of discharge measurements made in 1891 has been completed; also three of 1890 received in January, 1892. Results, with field reports, are appended (marked H).

High-water marks for the period reported have not been received. The gauge records received at date of report do not yet show the highest waters of the period. A table of lowest gauge readings exceeding those reported in the Annual Report for 1891, pages 3555–3575, is appended (marked I).

Current gauge records have been checked, tabulated, and platted on office hydrographs.

This work has been under charge of Assistant Engineer K. Tully, with Assistant Engineer George H. Johnson, and C. A. Bonfils, computer.

Plant.—The plant held under this allotment consists of the survey fleet (1 steamboat, 2 quarter boats, 14 row boats), the field and office instruments, the printing plant, and office furniture.

On January 1 the *Patrol* was sunk near Commerce Landing, Miss.; the circumstances are stated in connection with survey of Caving Banks.

Telegraphic report was received at this office on the 1st, and telegrams sent to Assistant Engineer Ockerson, who was at Memphis en route to inspect the work, and to Capt. Roessler, asking assistance. The services of the Halliday wrecking plant and diver, at Cairo (the only one known to the office), were engaged, and the steamer *Minnetonka* put in commission and a supply of lumber and tools put on board. (This was done in absence of the secretary, who returned from leave of absence on the morning of January 3.)

The *Minnetonka*, with wrecking boat in tow, arrived on January 4, and bulkheading was begun at once. The Halliday plant proved inefficient, and a boat with sand pump was engaged from the McNeely Towing Company at Memphis, on January 5.

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The work was carried on under great difficulty. The diver's work and the pumping were seriously impeded by the continuous cold. During the first half of the work the river was rising. Navigation was stopped by running ice during more than one week, and there was great difficulty in feeding the party as well as in obtaining supplies for the work.

On January 22 the boat was raised and floated by barges alongside. On the 28th she reached Cairo, but the ways being occupied, could not be hauled out at once. February 5–24 she was on the ways. Her hull had received little injury, but the labor of cleaning her was considerable. The outriggers of one side were crushed. Apart from the breaking of all connections by the displacement of the boilers and the breaking of the capstan engine, her machinery has suffered very little either from shock or submergence. It was cleaned as far as possible during the wrecking operations and well cared for. It is noteworthy that even steam-tight parts as valve boxes were found full of mud. February 24–April 18 repairs were completed with some changes in cabin, galley, quarters for deck crew, and coal bunkers. Boilers were inspected on April 23, and she returned to service same day. The repairs were under supervision of T. C. Hockridge, foreman, master of the boat for several years.

Quarter boat *Illinois*, repaired last year, is in fair condition. Quarter boat *Kentucky*, repaired last year, and then estimated as good for one year's service, carried the double-precise-level party from St. Paul to Savanna without accident. While being towed thence to Quincy, she showed such weakness as to prove her unfit for service as quarters; she may be useful for storage if fit for towing to the general service fleet at Cairo.

Field instruments are in good condition, except one transit, broken by a fall on the ice during survey of caving banks. Five precise-levels, with appurtenances, are in hands of Missouri River Commission.

The printing plant has been rearranged and refitted at a cost for day labor and lumber of about $60, and the fonts of type replenished, with gain of promptness of issue of printed records and publications of the Commission.

GENERAL SERVICE.

Stone supply.—On July 1, 1891, supply of stone to first and second and third districts was in progress; on that date 12,673 cubic yards were delivered, 6,447 en route. After that date deliveries were confined to first and second districts. This work was closed by the barges being required for service in the districts on September 7; 46,728 cubic yards in all were delivered, 33,526 to first district and 13,202 to third district. This work was delayed in its earlier stages by the quarries being flooded, and was in favorable progress during the last three weeks only; in these three weeks 16,535 cubic yards were delivered at Daniels Point and Fletchers, Ark. The loaded barges were left for service at place of last delivery, the unloaded sent on return of towboats.

The total piece and yard mileage for above were:

	Piece miles.	Yard miles.
First district	35,847	7,463,928
Third district	51,539	7,399,721
Total	87,386	15,043,649

The total expense of delivery (not including repair of plant nor interest on the value) was $24,883.24, or 1.6 + mills per yard per mile.

The stone was delivered on barges at 62½ cents per cubic yard; its transportation cost—

		Cents.
At Daniels Point	per cubic yard	36
At Fletchers	do	37
At Greenville	do	90

The purchase and delivery of 35,000 cubic yards of riprap stone was authorized on January 25 and of 15,000 cubic yards in addition on February 16. The barges were then still in use in the districts.

On notice that the barges were free for this service, the *Minnetonka* was sent out, on February 21, to collect them; as received they were cleaned, examined, and repaired, and refitted where necessary; loading began at the quarry on March 19.

On May 31 there had been delivered 12,600 cubic yards. About 3,500 cubic yards

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were loaded at quarry. This work has been delayed by rain and by rising water. The quarryman has floated his boilers and opened new fronts as the water rose, and has now done drilling probably sufficient for the whole delivery. With a fall of water loading can be done at a rate of about 1,000 yards per working day. Towing by *Mississippi* and *Minnetonka* can keep up with this.

Plant.—The plant held under this allotment consists of the general service fleet (4 towboats, 80 stone barges, 6 fuel barges, 1 store boat, 3 camel docks, 13 row boats, 2 calking flats, with their equipment), general tools, and office furniture.

Towboats.—The *Mississippi*, built in 1883, has had the damage by snagging (reported last year) repaired; a new roof has been laid; sleeping accommodations in forward cabin have been increased; the boat has been painted throughout. The *Minnetonka*, built in 1885, has been hauled out, her hull scraped and calked, her chain fastenings renewed. The *Etheridge*, built in 1880–'81, has had small repair, her boilers, already old when placed in her, were inspected in January, in the third district, and pressure allowed 125 pounds; she needs a new battery of boilers and general repair. The *Vedette*, used as a fleet tender, has had small general repair. All, except the *Etheridge*, are in good condition.

The stone barges are of four classes. Thirty, built in 1889–'90, 120 by 30 by 7 feet, framed, flush-decked, bottom-planked fore-and-aft, are in good condition. Twenty-six, built in 1883, 120 by 30 by 6 feet, gunwaled, sunk-decked, bottom planked and athwartship, repaired last year, some of them by sheathing, are still serviceable, but will not bear much more patching; most of them are worth rebuilding from the bottom at a probable cost two-thirds that of a new barge. Twenty-four, built in 1885, 100 by 25 by 5 feet, gunwaled, flush-decked, bottom planked athwartship, are in same condition as second class; of these, two carry cabins of old survey boats, and are used as quarter boats. All have had current repair in service during the period reported. The fuel barges, built in 1886, 120 by 25 by 6 feet, framed, without deck, are in good condition.

The store boat, an old coal barge (bought second-hand in 1885), covered with a slightly framed store house, has had general repair and is in fair preservation.

The camel docks, two built and one rebuilt in 1891, in frequent use during the period reported, are in good condition.

The *Mississippi* has been used on inspections by the Commission, and to a small extent in towing.

The *Minnetonka* has been used in towing, at wreck of *Patrol*, and as fleet tender in absence of smaller boats.

The *Etheridge* has been used in towing; on September 12 she was turned over to the third district for service during working season; she was towed back in the spring unserviceable for want of boiler power.

The *Vedette* has been used as fleet tender; on October 28 she was turned over to the third district for service during the working season; returned to the general service on March 10, and in service since as fleet tender.

The barges, except two used as quarter boats, and three retained in the districts for some time past, have been used in towing stone and as working barges in the districts.

The repair of model barges belonging to the third district was completed in September, 1891. They were sent down with last tow and by *Etheridge*. The plant while not in use, and for repair, has lain at Cairo during the period reported. No water front there is controlled by the Commission. No rent has been paid.

TONNAGE AND TRAFFIC, CALENDAR YEAR 1891.

The traffic on the sections of the Mississippi River, under charge of the Commission, is mainly carried on by lines of steamers and barges plying from St. Louis, Cincinnati, and Pittsburg to New Orleans and intermediate landings and to ports on Red River. The upstream loads are comparatively light. The custom-house records are of registered tonnage only. A statement is appended.

The Merchants' Exchange of St. Louis keeps, by calendar years, minute record of shipments and record of receipts in bulk. As freights from the upper river are reshipped here, this represents the northern traffic. Statements of shipment by New Orleans boats and by Memphis, Vicksburg, and Natchez boats, taken from their last annual statement, are appended. The last-mentioned line makes landings above the mouth of the Ohio; one-fourth of their shipments is deducted in preparing the table of commercial statistics for this report. The most important shipment from St. Louis is of grain in bulk for exportation; a detailed statement of this shipment from the Merchants' Exchange is appended.

This traffic was rendered difficult by low water till the middle of January and after the first week of August. From November 27 to December 20 no freights were shipped for New Orleans. The river was not closed by ice, though navigation has been impeded by running ice.

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The direct foreign shipment, via New Orleans, of grain in bulk aggregated in 1891 251,500 tons. The importance of this line of traffic is shown by the average rates of freight.

	Cents per bushel.
St. Louis to Liverpool, via river to New Orleans	15.75
St. Louis to Liverpool, via rail to New York	23.55

I quote two paragraphs from the report of the Merchants' Exchange of St. Louis; the second is from the statement of the Valley Line Transportation Company.

"The short wheat crops of Europe caused a large demand upon the United States for that cereal and large orders came to St. Louis. During July and August about 3,500,000 bushels were forwarded and there was a demand for all the barges could transport. But, unfortunately, early in August the river declined to a very low stage and so continued for the balance of the year, reducing the ability of the barge line to one-fourth of its usual capacity and for a portion of the time absolutely suspending navigation. Notwithstanding these hindrances 6,940,215 bushels of wheat, 1,482,731 bushels of corn and 45,600 bushels of rye were forwarded by river to New Orleans for export, and 1,575,321 bushels of wheat and 506,936 bushels of corn forwarded by rail to Cairo, Ill., and Belmont, Mo., and there taken by the barges, making 10,350,803 bushels of grain exported from St. Louis via the Mississippi River during 1891."

"The export trade, chiefly carried by barges, is of a character necessitating time contracts, often extending over a period of four to five months, and guaranteeing the delivery at New Orleans of given quantities of grain during the first and second half of certain months, thus fixed, far in advance. These contracts, being always attended by heavy penalty of vessel demurrage in case of failure, must be complied with at whatever loss; thus such unlooked for difficult and disastrous navigation falls especially heavy on the export as well as carrying interest of our river commerce."

The total traffic from St. Louis on Mississippi, below Cairo, and Red rivers, in 1891, is—

	Tons.
Shipments	416,150
Receipts	209,095
Total	625,245

Of the tonnage and traffic on the Lower Mississppi coming from the Ohio River, I can obtain little trustworthy information. Of the enrolled tonnage, the customhouse at Pittsburg can not separate that which plies on the Mississippi below Cairo; that at Paducah, owing to recent transfer, can give no report. Of the traffic, I have sought information from the Boards of Trade (or like organizations under other title) of all the leading cities; I have received reply from the Business Men's Association of Evansville only, reporting shipments of 7,000 tons. The reports of the district officers, who have authority to require this information from sailing masters, can not reach me in time for compilation.

I can therefore present, in addition to the above report of the Upper Mississippi, only the following incomplete statement of enrolled tonnage:

	Steamers.	Tons (net).	Barges.	Tons (net).
St. Louis	85	40,894	87	88,114
Cairo	14	3,069	(*)	(*)
Cincinnati	8	7,669	(†)	(†)
Evansville	None			
Paducah	No report.			
Pittsburg‡				

* Not enrolled.
† Not reported.
‡ Can not separate Lower Mississipi tonnage.

Financial statements, list of civilian engineers employed, and statement of plant are appended.

I have the honor to be, very respectfully, your obedient servant,

CARL F. PALFREY,
Captain of Engineers.

Gen. C. B. COMSTOCK,
Colonel of Engineers, President Mississippi River Commission.

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Secretary's office—financial statement for the month ending May 31, 1892.

	Mississippi River Commission, act Oct. 2, 1888.	Survey of Mississippi River, act Aug. 11, '88.	Improving Mississippi River, general service.	Improving Mississippi River, surveys, gauges and observations.	Improving Mississippi River, Mississippi River Commission.
Balance unexpended, July 1, 1891	$80.91	$7.08	$186,995.08	$118,181.87	$56,729.77
Amounts received since by transfer				2,000.00	
Total available	80.91	7.08	186,995.08	120,181.87	56,729.77
Expended from July 1, 1891, to date			74,291.60	72,845.45	20,478.85
Transferred			23,000.00		
Total disposed of			97,291.60	72,845.45	20,478.85
Balance	80.91	7.08	89,703.48	47,336.42	36,250.92
In treasury (refundment by Capt. Powell, for account Mississippi River Commission $57.35)	57.35		83,138.82	52,000.00	34,000.00
In hand	80.91	7.08	6,564.66		2,250.92
Due other works				4,663.58	
Total balance as above	138.26	7.08	89,703.48	47,336.42	36,250.92
Outstanding liabilities (estimated)	138.26	7.08	9,250.00	9,500.00	2,000.00
Amounts covered by existing contracts					
Total liabilities	138.26	7.08	9,250.00	9,500.00	2,000.00
Available balance			80,453.48	37,836.42	34,250.92

First and second districts—financial statement for the month ending May 31, 1892.

	Plum Point Reach.	Plant, first and second districts.	Hickman, Ky.	Memphis Harbor.	Helena, Ark.
Balance unexpended July 1, 1891	$426,025.78	$95,101.06	$47,370.42	$107,914.43	$22,502.80
Amounts received since by transfer, etc	50,000.00			6,000.00	
Total available	476,025.78	95,101.06	47,370.42	113,914.43	22,502.80
Expended from July 1, 1891, to date	189,717.08	82,254.06	1,459.45	105,404.93	
Transferred, etc	6,000.00				*21,000.00
Total disposed of	195,717.08	82,254.06	1,459.45	105,404.93	21,000.00
Balance	280,308.70	12,847.00	45,910.97	8,509.50	1,502.80
In Treasury	269,500.00	25,500.00	42,843.17		1,500.00
In hand	10,808.70		3,067.80	8,509.50	2.80
Due other works		12,653.00			
Total balance as above	280,308.70	12,847.00	45,910.97	8,509.50	1,502.80
Outstanding liabilities (estimated)	60,000.00	4,500.00			
Amounts covered by existing contracts	25,000.00				
Total liabilities	85,000.00	4,500.00			
Available balance	195,308.70	8,347.00	45,910.97	8,509.50	1,502.80

*$1,200 available for protection of levees, White River Basin; ——— available for protection of levees, second district, Yazoo front; $1,500 available for protection of levees, Upper Mississippi levee district.

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First and second districts—financial statement for the month, etc.—Continued.

	Levees, Upper Mississippi levee district.	Levees, White River Basin.	Levees, second district, Yazoo Front.	Preservation of works.	Surveys, gauges, and observations.	New Madrid, Mo.
Balance unexpended July 1, 1891..	$34,966.16	$118,866.15	$13,744.82	$18,516.52	$13,164.09	$1,000.00
Amounts received since by transfer, etc	....	4,183.00	5,104.00	....	....	....
Total available	34,966.16	123,049.15	18,848.82	18,516.52	13,164.09	1,000.00
Expended from July 1, 1891, to date.	31,523.71	120,644.43	14,146.57	7,476.63	5,549.80	773.39
Transferred, etc	....	331.17	....	....	....	....
Total disposed of	31,523.71	120,975.60	14,146.57	7,476.63	5,549.80	773.39
Balance	3,442.45	2,073.55	4,702.25	11,039.89	7,614.29	226.61
In Treasury	....	5,918.83	....	5,000.00	8,500.00	....
In hand	3,442.45	....	4,702.25	6,039.89	....	226.61
Due other works	....	3,845.28	....	....	885.71	....
Total balance as above	3,442.45	2,073.55	4,702.25	11,039.89	7,614.29	226.61
Outstanding liabilities (estimated).	1,500.00	500.00	426.22	....	500.00	....
Amounts covered by existing contracts	....	....	....	....	....	....
Total liabilities	1,500.00	500.00	426.22	....	500.00	....
Available balance	1,942.45	1,573.55	4,276.03	11,039.89	7,114.29	226.61

Third district—financial statement for the month ending May 31, 1892.

	Lake Providence Reach.	Vicksburg, Miss.	Greenville, Miss.	Ashbrook Neck.	Plant, third district.
Balance unexpended July 1, 1891...	$389,565.79	$84,464.40	$194,786.26	$214,961.85	$78,533.30
Amounts received since by transfer.	....	....	48,000.00	48,000.00	26,331.17
Total available	389,565.79	84,464.40	242,786.26	262,961.85	104,864.47
Expended from July 1, 1891, to date.	108,007.27	36,548.09	193,074.99	145,765.01	89,399.67
Transferred	247,000.00	3,000.00	....	6,000.00	....
Total disposed of	355,007.27	39,548.09	193,074.99	151,765.01	89,399.67
Balance	34,558.52	44,916.31	49,711.27	111,196.84	15,464.80
In Treasury	....	47,500.00	45,000.00	97,000.00	16,000.00
In hand	34,558.52	....	4,711.27	14,196.84	....
Due other works	....	2,583.69	....	....	535.20
Total balance as above	34,558.52	44,916.31	49,711.27	111,196.84	15,464.80
Outstanding liabilities (estimated).	3,558.52	2,916.31	1,711.27	8,196.84	3,464.80
Amounts covered by existing contracts	8,000.00	12,000.00	23,000.00	23,000.00	12,000.00
Total liabilities	11,558.52	14,916.31	24,711.27	31,196.84	15,464.80
Available balance	23,000.00	*30,000.00	25,000.00	80,000.00	....

* $15,000 reserved for Delta Point, La.

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Third district—financial statement for the month, etc.—Continued.

	Surveys, gauges, and observations.	Levees, lower Mississippi levee district.	Levees, Tensas Basin, third district, Ark.	Levees, Tensas Basin, third district, La.	Dry dock.	Lake Bolivar Front.
Balance unexpended July 1, 1891	$5,397.09	$89,743.99	$168,217.24	$38,908.18	$20,000.00	....
Amounts received since by transfer	....	17,961.15	43,897.00	54,565.97	....	$6,000.00
Total available	5,397.09	107,705.14	212,114.24	93,474.15	20,000.00	6,000.00
Expended from July 1, 1891, to date	4,871.71	104,615.48	146,228.87	87,497.00	19,988.57	....
Transferred	....	....	43,165.97	....	....	....
Total disposed of	4,871.71	104,615.48	189,394.84	87,497.00	19,988.57	....
Balance	525.38	3,089.66	22,719.40	5,977.15	11.43	6,000.00
In Treasury	1,000.00	7,000.00	18,000.00	....	12,500.00	6,000.00
In hand	....	....	4,719.40	5,977.15	....	....
Due other works	474.62	3,910.34	....	....	12,488.57	....
Total balance as above	525.38	3,089.66	22,719.40	5,977.15	11.43	6,000.00
Outstanding liabilities (estimated)	525.38	3,089.66	22,719.40	5,977.15	11.43	....
Amounts covered by existing contracts	....				....	1,000.00
Total liabilities	525.38	3,089.66	22,719.40	5,977.15	11.43	1,000.00
Available balance	....	....	....	....	....	5,000.00

Fourth district—financial statement for the month ending May 31, 1892.

	Levees, Tensas Basin.	Protection of levees, Tensas basin.	Levees, right bank below Red River.	Protection of levees, right bank below Red River.
Balance unexpended July 1, 1891	$117,532.16	$47,989.02	$16,510.15	$48,071.25
Amounts received since by transfer	54,352.25	10,677.75	55,472.40	3,732.10
Total available	171,884.41	58,666.77	71,982.55	51,803.35
Expended from July 1, 1891, to date	160,212.39	9,088.60	69,920.61	1,363.47
Transferred	....	41,475.00	....	41,562.50
Total disposed of	160,212.39	50,563.60	69,920.61	42,925.97
Balance	11,672.02	8,103.17	2,061.94	8,877.38
In Treasury	....	5,000.00	....	3,000.00
In hand	11,672.02	3,103.17	2,061.94	5,877.38
Due other works	....	....	....	....
Total balance as above	11,672.02	8,103.17	2,061.94	8,877.38
Outstanding liabilities (estimated)	100.00	1,200.00	....	3,500.00
Amounts covered by existing contracts (estimated)	11,522.31	....	....	....
Total liabilities	11,622.31	1,200.00	....	3,500.00
Available balance	49.71	6,903.17	2,061.94	5,377.38

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Fourth district—financial statement for the month, etc.—Continued.

	Levees, left bank below Red River.	Protection of levees, left bank below Red River.	New Orleans Harbor, La.	Red and Atchafalaya rivers.	Surveys, gauges, and observations.
Balance unexpended July 1, 1891	$5,717.14	$24,689.06	$69,719.54	$147,109.28	$5,700.50
Amounts received since by transfer	29,381.60	3,396.40	8,001.00	3,000.00	1,000.00
Total available	35,098.74	25,085.46	77,720.54	150,109.28	6,700.50
Expended from July 1, 1891, to date	34,146.71	1,788.00	72,952.21	52,237.55	5,318.97
Transferred		21,850.00		8,000.00	
Total disposed of	34,146.71	23,638.00	72,952.21	60,237.55	5,318.97
Balance	952.03	4,447.46	4,768.33	89,871.73	1,381.53
In Treasury		3,000.00		90,000.00	1,000.00
In hand	952.03	1,447.46	4,768.33		381.53
Due other works				128.27	
Total balance as above	952.03	4,447.46	4,768.33	89,871.73	1,381.53
Outstanding liabilities (estimated)		2,600.00			
Amounts covered by existing contracts (estimated)					
Total liabilities		4,700.00			
Available balance	952.03	1,847.46	4,768.33	89,871.73	1,381.53

Consolidated statement, March 3, 1881, to May 31, 1892.

Act of—		
March 3, 1881		$1,000,000.00
August 2, 1882		4,123,000.00
January 19, 1884		1,000,000.00
July 5, 1884, less $5,000 transferred to snag-boat service		2,065,000.00
August 5, 1886, less $5,942.60 for expenses, office Chief of Engineers		1,994,057.40
August 11, 1888, less $4,859 for expenses, office Chief of Engineers		2,840,141.00
September 19, 1890		3,200,000.00
March 3, 1891		1,000,000.00
Total specific appropriations		17,222,198.40
Balances from former appropriations applied to works below Cairo under act of August 2, 1882, less $123.42, reverted to Treasury	$272,504.96	
Same for works above Cairo, under act of July 5, 1884	22,632.53	
Total balances		295,137.49
Total available		17,517,335.89
Expended—		
Plum Point Reach		3,357,212.84
Memphis Harbor and Reach		1,149,132.93
Lake Providence		3,020,364.48
Red and Atchafalaya		696,849.82
Levees		4,690,442.56
Other works		3,616,958.08
Total		16,530,960.71
Balance May 31, 1892		986,375.18

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Detailed statement, March 3, 1881, to May 31, 1892. (Expended allotments.)

Districts.	Balances.	Appropriations and allotments.	Applied by general service.	Total.
Des Moines Rapids to Illinois River	$12,663.38	$195,000.00		$207,663.38
Illinois River to Ohio River	9,969.15	470,000.00		479,969.15
Total	22,632.53	665,000.00		687,632.53
Survey St. Francis Front		10,122.61		10,122.61
New Madrid Reach		200,721.86	$9,640.05	210,361.91
Columbus, Ky		41,150.92	2,599.08	43,750.00
Gauges		1,436.50		1,436.50
Observations and discharges		3,000.00		3,000.00
Surveys, examinations, and inspections		1,791.52		1,791.52
Levees—Plum Point		155,924.03		155,924.03
Survey St. Francis Front		4,000.00		4,000.00
Survey Helena Reach		8,000.00		8,000.00
Levees:				
Long Lake		15,000.00		15,000.00
Yazoo, Mississippi Delta		100,000.00		100,000.00
Protection of levees		1,595.55		1,595.55
Memphis Reach		147,384.47	52,696.32	200,080.79
Memphis Harbor and Reach		431,792.38	138,232.94	570,025.32
Gauges		987.50		987.50
Observations and discharges		3,000.00		3,000.00
Surveys, examinations, and inspections		1,880.11		1,880.11
Care of plant, first and second districts		84,998.64		84,998.64
Surveys, first and second districts		9,475.84		9,475.84
Total first and second districts		1,222,261.93	203,168.39	1,425,430.32
Survey Vicksburg Harbor		2,500.00		2,500.00
Survey Unleveed Fronts		1,000.00		1,000.00
Survey Choctaw Reach		2,679.86		2,679.86
Levees:				
Opossum Fork		120,000.00		120,000.00
Yazoo Front		364,878.95		364,878.95
Yazoo Front—Ben. Lomond		11,386.22		11,386.22
Yazoo Front—Hughes Break		6,849.69		6,849.69
Tensas Front		566,723.00		566,723.00
Protection of levees		216,431.83		216,431.83
Protection of existing works		25,000.00		25,000.00
Repairs to Floating Plant		30,000.00		30,000.00
Vicksburg Harbor, Delta Point	25,770.13	107,579.88		133,350.01
Care of plant and surveys		24,360.00		24,360.00
Lake Bolivar Front		116,329.85	8,028.19	124,358.04
Gauges		1,461.10		1,461.10
Observations and discharges		3,000.00		3,000.00
Surveys, examinations, and inspections		10,149.46		10,149.46
Total third district	25,770.13	1,610,329.84	8,028.19	1,644,128.16
Survey Cubitts Gap		137.14		137.14
Survey Unleveed Fronts		1,000.00		1,000.00
Observations at Carrollton		3,000.00		3,000.00
Bonnet Carre Crevasse		15,000.00		15,000.00
Natchez and Vidalia Harbors	8,252.04			8,252.04
Mouth of Red River	90,812.40	38,405.00		129,217.40
Natchez, Miss. (survey)		1,500.00		1,500.00
Gauges		1,878.11		1,878.11
Observations and discharges		9,000.00		9,000.00
Levees—Atchafalaya Front		176,800.00		176,800.00
Protection of levees, Tensas Front		23,000.00		23,000.00
Protection of levees		104,000.00		104,000.00
Surveys, examinations, and inspections		4,000.00		4,000.00
Total fourth district	99,064.44	377,720.25		476,784.69
Reduction of observations		2,500.00		2,500.00
Total secretary's office		2,500.00		2,500.00
Grand total	147,467.10	3,877,812.02	211,196.58	4,236,475.70

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Detailed statement, March 3, 1881, to May 31, 1892. (Current allotments.)

Districts.	Balances.	Appropriations and allotments.	Applied by general service.	Total available.
Protection near Cairo		$50,000.00		$50,000.00
Totals above Cairo		50,000.00		50,000.00
Plum Point Reach		3,296,821.18	$340,700.36	3,637,521.54
Hickman, Ky		85,843.17	3,288.83	89,132.00
New Madrid (survey)		1,000.00		1,000.00
Levees:				
Yazoo Front		161,304.00		161,304.00
White River Basin		271,351.83		271,351.83
Upper Mississippi levee district		140,000.00		140,000.00
Memphis Harbor		380,365.53	7,170.79	387,536.32
Helena		66,106.83	10,393.17	76,500.00
Plant, first and second districts		130,507.35	3,642.24	134,149.59
Preservation of works		20,680.42	3,187.47	23,867.89
Surveys, gauges, and observations		18,479.03		18,479.03
Total first and second districts		4,572,459.34	368,382.86	4,940,842.20
Levees:				
Tensas Basin, Ark		398,445.21		398,445.21
Tensas Basin, La		160,349.74		160,349.74
Lower Mississippi Levee district		290,035.55		290,035.55
Greenville, Miss		348,499.02	56,747.65	405,246.67
Vicksburg		366,968.70	2,662.27	369,630.97
Lake Providence Reach		2,799,876.34	255,046.96	3,054,923.30
Ashbrook Neck		342,000.00	49,003.87	391,003.87
Lake Bolivar Front		6,000.00		6,000.00
Plant		156,331.17	15,720.38	172,051.55
Dry dock		20,000.00		20,000.00
Surveys, gauges, and observations		12,138.90		12,138.90
Total third district		4,900,644.63	379,181.13	5,279,825.76
New Orleans Harbor	$147,670.39	389,183.86	1,527.61	538,381.86
Red and Atchafalaya rivers		657,500.00		657,500.00
Surveys, gauges, and observations		13,121.89		13,121.89
Levees:				
Tensas Basin		1,163,477.00		1,163,477.00
Right bank below Red River		191,892.00		191,892.00
Left bank below Red River		129,116.00		129,116.00
Total fourth district	147,670.39	2,544,290.75	1,527.61	2,693,488.75
General service		89,703.48		89,703.48
Mississippi River Commission		75,000.00		75,000.00
Surveys, gauges, and observations		152,000.00		152,000.00
Total secretary's office		316,703.48		316,703.48
Grand total	147,670.39	12,384,098.20	749,091.60	13,280,860.19

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Detailed statement, March 3, 1881, to May 31, 1892. (Current allotments)—Continued.

	Expended.	In Treasury.	On hand.	Due other works.	Balances.
Protection near Cairo	$41,400.00		$8,600.00		$8,600.00
Totals above Cairo	41,400.00		8,600.00		8,600.00
Plum Point Reach	3,357,212.84	$269,500.00	10,808.70		280,308.70
Hickman, Ky	43,221.03	42,843.17	3,067.80		45,910.97
New Madrid (survey)	773.39		226.61		226.61
Levees:					
Yazoo Front	156,601.75		4,702.25		4,702.25
White River Basin	269,278.28	5,918.83		$3,845.28	2,073.55
Upper Mississippi Levee district	136,557.55		3,442.45		3,442.45
Memphis Harbor	379,026.82		8,509.50		8,509.50
Helena	74,997.20	1,500.00	2.80		1,502.80
Plant, First and Second district	121,302.59	25,500.00		12,653.00	12,847.00
Preservation of works	12,828.00	5,000.00	6,039.89		11,039.89
Surveys, gauges, and observations	10,864.74	8,500.00		885.71	7,614.29
Total First and Second district	4,562,664.19	358,762.00	36,800.00	17,383.99	378,178.01
Levees:					
Tensas Basin, Ark	375,725.81	18,000.00	4,719.40		22,719.40
Tensas Basin, La.	154,372.59		5,977.15		5,977.15
Lower Mississippi Levee district	286,945.89	7,000.00		3,910.34	3,089.66
Greenville, Miss	355,535.40	45,000.00	4,711.27		49,711.27
Vicksburg	324,714.66	47,500.00		2,583.69	44,916.31
Lake Providence Reach	3,020,364.78		34,558.52		34,558.52
Ashbrook Neck	279,807.03	97,000.00	14,196.84		111,196.84
Lake Bolivar Front		6,000.00			6,000.00
Plant	156,586.75	16,000.00		535.20	15,464.80
Dry dock	19,988.57	12,500.00		12,488.57	11.43
Surveys, gauges, and observations	11,613.52	1,000.00		474.62	525.38
Total Third district	4,985,655.00	250,000.00	64,163.18	19,902.42	294,170.76
New Orleans Harbor	533,613.53		4,768.33		4,768.33
Red and Atchafalaya rivers	567,628.27	90,000.00		128.27	89,871.73
Surveys, gauges, and observations	11,740.36	1,000.00	381.53		1,381.53
Levees:					
Tensas Basin	1,143,701.81	5,000.00	14,775.19		19,775.19
Right bank below Red River	180,952.68	3,000.00	7,939.32		10,939.32
Left bank below Red River	123,716.51	3,000.00	2,399.49		5,399.49
Total Fourth district	2,561,353.16	102,000.00	30,263.86	128.27	132,135.59
General service		83,138.82	6,564.66		89,703.48
Mississippi River Commission	38,749.08	34,000.00	2,250.92		36,250.92
Surveys, gauges, and observations	104,663.58	52,000.00		4,663.58	47,336.42
Total secretary's office	143,412.66	169,138.82	8,815.58	4,663.58	173,290.82
Grand total	12,294,485.01	879,900.82	148,642.62	42,168.26	986,375.18

List of civilian engineers employed on work of river and harbor improvements in charge of Capt. Carl F. Palfrey, Corps of Engineers, to May 31, 1892, inclusive.

Name and residence.	Time employed. M.	Time employed. D.	Compensation.	Where employed.	Work on which employed.
J. A. Ockerson, St. Louis, Mo	11	00	$250	St. Louis, Mo	In charge survey (S. G. & O.).
Kivas Tully, St. Louis, Mo	11	00	175	do	In charge computations (S. G. & O.).
C. W. Clark, St. Louis, Mo	11	00	175	do	Platting maps (S. G. & O.).
Charles W. Stewart, St. Louis, Mo.	11	00	150	In the field and in St. Louis, Mo.	Surveys, and reduction of field notes.
O. W. Ferguson, St. Louis, Mo	8	15	175		
James A. Paige, St. Louis, Mo	8	15	150		
F. B. Maltby, Champaign, Ill	1	00	140		
Do	5	28	160		
A. T. Morrow, Mendota, Ill	1	00	125		
Do	6	14	140		
Do	4	16	160		
A. L. Johnson, St. Louis, Mo	2	20	150		
George H. French, Milton, Ill	2	00	120		

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Approximate value of plant belonging to the United States and used in improving Mississippi River from the head of the passes to the mouth of the Ohio River.

Allotment.	Class of property.	No.	Approximate value May 31, 1892.
Mississippi River Commission	Furniture, etc	.....	$100
Surveys, gauges, and observations	Steamboat Patrol, with outfit	1	11,000
	Quarter boats, with outfit	2	2,250
	Rowboats	14	175
	Surveying instruments	.....	12,500
	Current meters	8	1,250
	Drawing instruments	.....	750
	General tools	.....	500
	Printing plant	.....	750
	Office furniture	.....	600
General service	Steamboat Mississippi, with outfit	1	42,500
	Steamboat Minnetonka, with outfit	1	27,000
	Steamboat Emma Etheridge, with outfit	1	12,000
	Steamboat Vedette, with outfit	1	4,250
	Stone barges:		
	First-class	30	60,000
	Second-class	26	37,000
	Third-class	24	20,500
	Fuel barges	6	9,000
	Store boat	1	400
	Camel dock	1	1,500
	Rowboats	13	200
	Calking flat	2	40
	General tools	.....	100
	Office furniture	.....	475

Shipment of bulk grain by river to New Orleans during 1891.

Date.		Name of boat.	Corn.	Wheat.	Rye.	Grain bulk.	Other freight.	Total.
			Bushels.	*Bushels.*	*Bushels.*	*Tons.*	*Tons.*	*Tons.*
Jan.	7	My Choice and barges	22,785			637	773	1,410
	9	Jay Gould and barges	93,810			2,625		2,625
	20	My Choice and barges		44,700		1,340		1,340
	22	Sidney Dillon and barges }		32,210		966	1,654	2,620
	24	My Choice and barges }						
	27	Sidney Dillon and barges		58,800		1,765		1,765
	30	My Choice and barges	42,200			1,680		1,680
Feb.	1	Sidney Dillon and barges	41,000			1,150		1,150
	3	My Choice and barges	17,000			475	1,745	2,220
	6	Sidney Dillon and barges	47,000			1,315		1,315
	10	My Choice and barges					1,785	1,785
	13	Sidney Dillon and barges	45,400			1,270		1,270
	14	My Choice and barges	41,000			1,150		1,150
	17	Sidney Dillon and barges	21,000			588	1,917	2,505
	24	My Choice and barges	93,000			2,605		2,605
Mar.	1	......do	50,000	43,500		2,705		2,705
	1	Sidney Dillon and barges	87,141			2,440	1,055	3,495
	10	Gilmore, Choice, and Dillon barges	157,500			4,410	1,495	5,905
	15	Sidney Dillon and barges	62,200	29,000		2,610		2,610
	15	My Choice and barges	40,000			1,120		1,120
	15	John Gilmore and barges	75,800			2,120	875	2,995
	19	Sidney Dillon and barges		82,526		2,475		2,475
	19	My Choice and barges	37,000	57,000		2,745		2,745
	20	Jay Gould and barges		32,000		960		960
	25	My Choice and barges		131,500		3,945		3,945
	25	Sidney Dillon and barges		46,000		1,380	1,065	2,445
	30	My Choice and barges	72,000	40,000		3,216	1,494	4,710
Apr.	5	Henry Lourey and barges	150,000			4,500		4,500
	5	My Choice and barges					2,255	2,255
	12	......do	42,500			1,190	1,315	2,505
	12	John Gilmore and barges		141,737		4,250		4,250
	18	My Choice and barges		141,021		4,230		4,230
	18	H. M. Hoxie and barges		80,521		2,415	1,545	3,960
	25	Oakland and barges	73,264			2,050	2,470	4,520
May	3	My Choice and barges		156,700		4,700		4,700
	3	Future City and barges					1,185	1,185
	9	Henry Lourey and barges }	20,000	64,323		2,490	2,625	5,115
	9	My Choice and barges }						
	18	John Gilmore and barges					1,315	1,315
	23	H. M. Hoxie and barges		98,346		2,950	1,425	4,375
	31	Oakland and barges		64,581				
June	7	Henry Lourey and barges	45,258			1,265	2,205	3,470
	13	John Gilmore and barges	51,213	25,000		1,432	1,593	3,025
	23	H. M. Hoxie and barges					1,850	1,850
	28	Oakland and barges					1,270	1,270

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Shipment of bulk grain by river to New Orleans during 1891—Continued.

Date.	Name of boat.	Corn.	Wheat.	Rye.	Grain bulk.	Other freight.	Total.
		Bushels.	*Bushels.*	*Bushels.*	*Tons.*	*Tons.*	*Tons.*
July 8	S. H. H. Clark and barges	29,770	95,030		3,685	1,200	4,885
11	John Gilmore and barges	24,890	105,352		3,860	705	4,565
11	Future City and barges		67,000		2,010		2,010
15	John Gilmore and barges		135,533		4,065		4,065
16	Henry Lourey and barges		46,000		1,380	910	2,290
18	Sidney Dillon and barges		109,500		3,285	575	3,860
18	John Gilmore and barges		90,509		2,715		2,715
21	Sidney Dillon and barges		129,471		3,885		3,885
23	H. M. Hoxie and barges		85,379		2,560	1,115	3,675
25	Oakland and barges		124,250		3,725		3,725
26	Sidney Dillon and barges		82,500		2,475	1,160	3,635
28	Jay Gould and barges		131,500		3,945		3,945
30	S. H. H. Clark and barges		101,000		3,030	575	3,605
30	Sidney Dillon and barges		126,337		3,790		3,790
Aug. 1	Jay Gould and barges		85,673		2,570	1,085	3,655
4	Sidney Dillon and barges		121,200		3,635		3,635
5	Jay Gould and barges		97,500		2,925	530	3,455
8	do		121,705		3,650		3,650
9	My Choice and barges		83,646		2,510	1,015	3,525
10	Jno. Gilmore and barges		108,695		3,260		3,260
12	Jay Gould and barges		111,500		3,345		3,345
12	My Choice and barges		102,100		3,065	420	3,485
14	Sidney Dillon and barges		105,520		3,165		3,165
16	My Choice and barges		92,549		2,775		2,775
18	Sidney Dillon and barges		94,465		2,835		2,835
19	Jay Gould and barges		108,883		3,265		3,265
21	My Choice and barges		79,858		2,395	1,025	3,420
23	Sidney Dillon and barges		129,100		3,875		3,875
23	Jay Gould and barges		139,839		4,135		4,135
25	My Choice and barges		129,500		3,885		3,885
26	Sidney Dillon and barges		86,700		2,600	1,020	3,620
27	Jay Gould and barges		117,029		3,510		3,510
29	My Choice and barges		120,297		3,610		3,610
Sept. 2	Sidney Dillon and barges		30,000		900	1,040	1,940
3	Jay Gould and barges		79,700		2,390		2,390
4	My Choice and barges		74,750		2,240		2,240
7	E. M. Norton and barges		77,210		2,315		2,315
7	J. P. Jackson and barges		129,938		3,905		3,905
9	My Choice and barges		45,300		1,350	745	2,095
11	Sidney Dillon and barges		67,200		2,015		2,015
13	Jay Gould and barges		40,300		1,210	535	1,745
15	My Choice and barges		43,000	21,600	1,895		1,895
16	E. M. Norton and barges		18,500	24,000	1,225	595	1,820
22	E. M. Norton and barges		40,939		1,229	626	1,855
23	My Choice and barges		53,000		1,590		1,590
25	Sidney Dillon and barges		35,500		1,065	520	1,585
30	My Choice and barges		34,100		1,025	625	1,650
Oct. 13	Sidney Dillon and barges		64,400		1,930		1,930
13	Jay Gould and barges		65,400		1,960		1,960
18	My choice and barges		63,632		1,910		1,910
21	Sidney Dillon and barges		61,500		1,845		1,845
21	Jay Gould and barges		59,000		1,770		1,770
24	My Choice and barges		53,480		1,605		1,605
27	Sidney Dillon and barges		54,500		1,635		1,635
29	Jay Gould and barges		56,422		1,690		1,690
Nov. 2	My Choice and barges		51,200		1,535	85	1,620
12	E. M. Norton and barges		45,492		1,365		1,365
12	Jay Gould and barges		56,000		1,680		1,680
12	My Choice and barges		46,300		1,390		1,390
18	Sidney Dillon and barges		42,200		1,265		1,265
20	Jay Gould and barges		46,000		1,380		1,380
23	My Choice and barges		46,500		1,395		1,395
25	E. M. Norton and barges		70,000		2,100		2,100
25	Jay Gould and barges		66,000		1,980		1,980
27	My Choice and barges		56,900		1,705		1,705
Dec. 21	John Gilmore and barges		77,610		2,330	390	2,720
24	Jay Gould and barges		54,850		1,645		1,645
28	Sidney Dillon and barges		55,800		1,675		1,675
29	John Gilmore and barges		54,000		1,620		1,620
29	Jay Gould and barges		54,700		1,640		1,640
31	do		34,300		1,030		1,030
Total		1,482,731	6,940,215	45,600	249,018	51,407	300,425
Via Belmont and Cairo:							
January		115,517			3,233		3,233
July			184,500		5,535		5,535
August			121,325		3,639		3,639
September			132,150		3,964		3,964
October			148,000		4,440		4,440
November			424,466		12,733		12,733
December		506,936			14,194		14,194
Total movement		2,105,184	7,950,656	45,600	296,756	51,407	348,163

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Shipments by New Orleans boats and barges for three years.

Articles.		1891.	1890.	1889.
Apples	barrels	144	348	427
Ale and beer	packages	1,892	2,503	2,258
Bagging	pieces	22,973	38,276	78,731
Barley	sacks	4	39	5
Barbed wire	pounds	253,864	1,831,163	550,343
Butter	do	1,105	9,377	3,014
Bran	sacks	46,507	70,746	75,821
Cattle	head	1	5	41
Corn	sacks	96,984	152,903	161,252
Corn in bulk	bushels	1,482,731	8,717,850	12,398,955
Corn meal	barrels	80,905	133,697	125,979
Cotton	bales	....	2,054	801
Eggs	packages	....	2	....
Flour	barrels	222,329	330,300	297,980
Hay	tons	754	956	2,214
Horses and mules	head	243	704	536
Hogs	do	23	24	5
Hominy and grits	barrels	23,978	40,247	26,400
Pork	do	5,896	6,279	4,956
Hams	pounds	85,194	131,926	127,840
Meats	do	1,143,318	1,789,865	2,135,711
Lard	do	6,869,290	8,116,580	7,969,345
Malt	sacks	....	15,845	9,235
Oats	do	257,728	403,173	407,874
Oats in bulk	bushels	....	89,960	89,707
Onions	packages	270	153	127
Potatoes	do	245	656	587
Rye	sacks	42	1,036	50
Rye in bulk	bushels	45,600	....	17,482
Tallow	pounds	....	220	....
Tobacco, manufactured	do	7,473	36,757	30,185
Wheat	sacks	207	418	241
Wheat in bulk	bushels	6,940,215	1,409,440	1,651,950
Whisky	barrels	402	1,046	1,013
White lead	pounds	1,050,481	1,184,295	1,867,378
Merchandise and sundries	packages	87,887	189,651	178,480
Total	tons	331,850	418,400	518,380

Shipments by Memphis, Vicksburg, and Natchez boats for three years.

Articles.		1891.	1890.	1889.
Apples	barrels	1,112	2,926	4,221
Ale and beer	packages	34,003	33,127	33,434
Bagging	pieces	56,233	40,349	70,454
Barley	sacks	234	577	237
Barbed wire	pounds	2,034,106	879,045	949,598
Butter	do	31,540	94,761	79,656
Bran	sacks	26,393	39,533	57,889
Cattle	head	34	77	29
Corn	sacks	144,563	119,403	98,730
Corn meal	barrels	157,012	201,964	172,931
Eggs	packages	56	270	....
Flour	barrels	131,358	173,970	178,713
Hay	tons	2,675	3,488	3,290
Horses and mules	head	1,545	1,834	1,505
Hogs	do	82	181	266
Hominy and grits	barrels	3,466	4,778	3,006
Pork	do	5,738	7,507	7,894
Hams	pounds	491,238	791,112	602,447
Meats	do	11,089,187	13,066,078	7,377,798
Lard	do	1,284,463	1,338,629	1,571,846
Malt	sacks	50	362	40
Oats	do	116,009	123,234	112,348
Onions	packages	3,357	2,246	3,211
Potatoes	do	12,359	13,365	12,153
Rye	sacks	381	1,378	427
Sheep	head	160	6	....
Tobacco	hogshead	2	....	....
Tobacco, manufactured	pounds	242,185	489,368	360,329
Wheat	sacks	370	173	384
Whisky	barrels	3,023	2,909	2,546
White lead	pounds	495,717	536,637	646,503
Merchandise and sundries	packages	872,774	1,091,650	1,036,339
Total tons		112,420	125,405	114,315

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APPENDIX 4 A.

REPORT OF ASSISTANT ENGINEER CHAS. W. STEWART ON SECONDARY TRIANGULATION FROM KEOKUK, IOWA, TO PORT LOUISA, IOWA, WITH TABULATED RESULTS, DESCRIPTIONS OF STATIONS, AND PLAT OF TRIANGULATION.

ST. LOUIS, MO., *November 15, 1891.*

CAPTAIN: I have the honor to submit the following detail report of secondary triangulation from Keokuk, Iowa, to Port Louisa, Iowa, done in May, June, and July, 1891.

The work ordered consisted of secondary triangulation beginning at Keokuk on a base measured in 1891 by Assistant Eisenman, and later by Assistant G. Y. Wisner, the azimuth of which had been determined by Assistant Eisenman, the work to extend northward. A reconnoissance and location of stations had been made by Assistant F. B. Maltby in March and April of this year. There was required a base and azimuth at New Boston, Illinois.

The party were quartered on the steamer *Patrol* and quarter-boat *Illinois*. The *Patrol* left St. Louis with quarter-boat *Illinois* and *Kentucky* in tow on April 25, arrived at Keokuk on April 27, proceeded to St. Paul with the *Kentucky*, and returned to Keokuk on May 4.

The party consisted of Assistant Charles W. Stewart in charge, and Assistants F. B. Maltby, A. T. Morrow, G. H. French, Recorders C. L. Ockerson, O. N. Axtell, F. W. Clay, and Rodman E. W. Robinson: master of steamer T. C. Hockridge, Pilot William Kelly, Steam Engineer W. E. Mead, 1 fireman, 1 watchman, a galley force of 4, and about 15 axemen and skiffmen, making a total force of about 32 men.

Instruments.—The instruments furnished were Throughton & Simms theodolites Nos. 1, 2, and 12, Little Gambey No. 2, Wurdeman 10-inch transit No. 193, B. & B. transit 611, and B. & B. level 617, Missouri River Commission tape marked II and the tension apparatus used during the preceding seasons by Mr. O. B. Wheeler. For protection from sun and wind two large umbrellas and a 7 feet by 14 feet canvas windbreak were used. Portable observing tripods with brass shifting heads furnished supports for secondary instruments.

The stations, Rapids, Lower Base, and Upper Base of Assistant Eisenman were occupied and the triangle filled, and the angles denoted a shifting of the surface marks at the bases. When the surface marks were removed it was found that relative to the buried mark lower base had shifted 0.016 meters and upper base 0.036 meters. The buried mark at upper base had its surface about 1¼ feet below water surface in the canal, was about 35 feet from the bank of canal, and in slope of railway embankment. As lower base and rapids were in higher ground the length and azimuth of the line joining them was taken from office manuscripts as the length and azimuth for base, viz .·. △ Rapids to △ Lower Base is 1595.485 meters and its azimuth 76° 29′ 30″.75. Coördinates of △ Rapids 40° 25′ 16.″66 N. 91° 21′ 49.″71 W. Coördinates of △ Lower Base 40° 25′ 04.″ 58 N. 91° 22′ 55.″52.

These latitudes and longitudes are referred to the astronomical post at Cairo.

The secondary angles were read by Mr. Maltby and myself. Mr. Morrow located stone lines and did the incident tertiary triangulation. Mr. French had the work of building stations and clearing lines. Mr. Hockridge rendered assistance in relocating stations, clearing lines, etc.

The monuments for triangulation stations were 18 inches by 18 inches by 4 feet vitrified tile and the capped 4-inch iron pipe, all suitably marked. A similar monument was used for stone-line bench marks. The geodetic mark was a cross in top of copper bolt leaded vertically into center of tile. This mark was transferred to the surface by means of a straight edge and plumb bob, the surface mark being a small depression in center of cap. Generally the top of pipe was 8 inches above the surface of ground and the bottom of tile 3 feet 8 inches below. The bronze bolts securing the cap were always set up tight with a wrench before leaving the station, to prevent their easy removal with the fingers.

The targets.—Phaseless targets were used throughout the season. At first the targets were of the usual pattern, and consisted of four vertical galvanized-iron wires arranged equidistantly about horizontal circles, and divided into zones by cloth strips stretched between opposite uprights, making sections through the axis of the cylinder. Targets of varying diameters were required for varying lengths of triangle sides, and Chief Assistant Ockerson devised a target whose section was diamond-shaped, and which was about 15 inches wide at center, and came to a point at each end. Zones of white cloth passed through the axis of the target, and the target was light, stiff, easily plumbed, and the narrowest visible portion was used for sighting.

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This target supplies in itself a phaseless target of varying width, well adapted to varying length of triangle sides, and its shape serves to identify it. These targets were supported by wire guys. When placed on ground stations it was necessary to build wire fences around them to prevent horses and cattle from destroying them.

Stations.—The nature of the country required the building of observing stations, and twenty stations, with an average height of 22 feet, were built, at an average cost of about $20 each, of sawed lumber. This cost includes cost of lumber, hauling to station, and labor of erection. The stations built consisted of a tripod firmly anchored in the ground and a platform entirely disconnected from the tripod. Six men can erect a 30-foot station in one day, or nine hours. The following bills show the amount of lumber in an 18-foot and 36-foot station, including a ladder:

For 36-foot station:

6 pieces, 4 by 4 inches by 18 feet.	801 feet, B. M.
33 pieces, 2 by 4 inches by 18 feet.	
19 pieces, 2 by 4 inches by 14 feet.	
16 pieces, 1 by 6 inches by 14 feet.	

For 18-foot station:

3 pieces, 4 by 4 inches by 18 feet.	407 feet, B. M.
3 pieces, 2 by 4 inches by 16 feet.	
11 pieces, 2 by 4 inches by 14 feet.	
8 pieces, 1 by 6 inches by 14 feet.	
12 pieces, 2 by 4 inches by 18 feet.	

The reconnoissance having been made when there was little or no foliage, lines which had been once seen over required sometimes considerable clearing and trimming and the reading of clearing angles.

The programme of observations was as per instructions. For all secondary angles readings were taken positive and negative with telescope direct. The limb was then shifted 22½°, and readings taken postive and negative with telescope reversed, etc., till eight results were obtained at equidistant points about the circle. The run of micrometer was noted daily and was very small. Vertical angles were read to stations. During a part of the season hazy weather made heliotroping necessary. The method was as follows: The heliotroper would cut a small hole in the target near its base and place a support or rest, so that from the point of rest the flash of the observing party could be seen. A small hand mirror was held with its center at the point of support and the sunlight reflected so as to cover the hole in the target.

The tertiary triangulation was connected with the secondary by well-conditioned triangles. Its purpose was to locate the stone line bench marks, and is always self checking.

The *Patrol* and *Illinois* were kept together the entire season. They were moved from Keokuk to Montrose, Iowa, on May 19; to Island No. 394 on May 27; to Fort Madison, Iowa, on May 31; to Burlington, Iowa, on June 14; to Oquawka on June 30; to Keithsburg, Ill., on July 3; and to New Boston, Ill., on July 10.

At New Boston a base line had been located on July 4. This line is 28 inches south of south rail of Chicago, Burlington and Quincy Railroad, which runs east and west from New Boston and is a tangent. The base length was about 18,066 feet, and its length was transferred to the triangulation stations east base–west base, which were near the termini of the base line. It was measured with steel tape marked II of the Missouri River Commission, and the method was substantially the same as that previously employed by the Mississippi River Commission. On this line was an old trestle 800 feet long. To insure firmness to tape supports a 3 by 6 inch stringer was spiked to the outer ends of bridge ties and all stakes fastened to this stringer. For temperature three thermometers were read, at the 50-foot, 150-foot and 250-foot marks respectively, the bulbs near the tape, and they were read at the moment of marking. The tape lengths were marked on zinc strips and the record preserved. The portion over the trestle was remeasured during the first measurement to test its accuracy. The terminal posts and post 28 were of seasoned pine, 6 by 6 inches, set 5 feet in the ground. Their centers were side-lined to notice any change in position.

The complete measurements were made on July 17. The actual time of measuring the 120 tapes was 261 minutes, an average of 1 tape in 2.2 minutes. The fractional portion of a tape (65 feet) at east base was duplicated with the tape. The fractional portions of 1 foot were measured with a silver scale whose length is correct within .01 inch. The discrepancy between these measurements was 1 in 254,000. As most of this discrepancy lay between post 28 and east base, this portion was remeasured at dawn on July 20, and a result obtained which agreed with the second measurement by 1 in 4,600,000. By rejecting the first measurement, the probable error of the base length is 1 in 1,933,000. By accepting all results, the mean errors give a prob-

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able error of about 1 in 750,000, which corresponds to an uncertainty of temperature of 0.1° F. The results are as follows:

Items.	Section 1, No. 0–No. 28.		Section 2, No. 28–No. 61.		
	First measure.	Second measure.	First measure.	Second measure.	Third measure.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Measured length	8, 401. 0783	8, 401. 0783	9, 666. 2407	9, 666. 2407	9, 666. 2407
Temperature correction	+0. 5838	+0. 7092	+0. 8347	+0. 8461	—0. 6144
Setbacks and transfers	—1. 6167	—1. 7275	—0. 7067	—0. 6617	+0. 7967
Standard results	8, 400. 0454	8, 400. 0600	9, 666. 3687	9, 666. 4251	9, 666. 4230
Mean results	....	8, 400. 0527	....	....	9, 666. 4056

	Feet.
Combined result	18, 066. 4583
Inclination correction	—0. 2437
Sea-level correction	—0. 5275
Transfer to a △ side	+0. 0900
△ West base–△ east base	18, 065. 7771
	Meters.
Log 3,740.8678	5, 506..0000

Azimuth at New Boston.—Azimuth was observed for on four nights, using * Polaris near elongation (east) and the observations were complete for three nights, but on 24th the clouds prevented completion. The observations were made on July 22, 23, 24, and 25 with T. & S. theodolite No. 12. Time was determined by comparison of sidereal chronometer 220 (Bond & Son) with the 10 a. m. time signal of the Chicago, Burlington and Quincy Railroad, and also by observing transit of high and low stars, π and Θ Herculis, θ Ophiuchi and γ^2 Sagittarii.

Observations were made with an artificial horizon of mercury, and pointings made to star and image as follows:

Programme (1):
Point to mark with circle right.
Point to star and note time.
Point to image and note time.
Point to mark.

Programme (2):
Shift limb 45°, then with circle left.
Point to mark.
Point to star and note time.
Point to image and note time.
Point to mark, etc.

This programme was followed for four observations at equidistant points around the circle. The striding level was not read. The combined results are as follows, one-half weight being given to the observation of July 24:

Azimuth line △ west base – △ east base observation polaris—

July 22	253°	18′	49″.00
July 23			47″.84
July 24			50″.44
July 25			49″.85
△ West base – △ east base	253°	18′	49″.06

Probable error ∓ 0″.38.

The use of the mercury horizon presents a great advantage, in that the determination of the angle between star and mark (or the taking of one observation) occupies a minimum of time, the correction of striding level and inequality of axis is eliminated in the method, and probably small level errors are eliminated, for the mean of all the single observations gives the resulting quantity as 0″.02 greater than the combined result adopted.

The two triangles north of the base line were filled, completing the triangulation to Port Louisa, Iowa, and as the *Patrol* and *Illinois* were required for service on topography, the location of stone line 135 at Port Louisa being completed at noon on 28th of July, the boats started for St. Louis in the afternoon.

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Summary.—The time from leaving St. Louis to returning to same point was 96 days; 6 days were given to moving only; there were 14 Sundays and 1 holiday; 12 days were lost because of fog or rain, leaving 63 working days.

The work done consists of carrying secondary triangulation 78 miles and the location of 24 stone lines.

Secondary stations occupied	40
Secondary triangles closed	39
Square miles covered	320
Tertiary points located (other than B. Ms.)	8
Tertiary triangles closed (location of B. Ms.)	88
Stone-line B. Ms. located	81

We are indebted to Mr. M. Meigs, United States civil engineer, for many courtesies rendered.

There was considerable sickness in the party, and several cases of malarial fever were developed.

The officers were zealous and efficient, the men sober and industrious.

Respectfully submitted.

CHAS. W. STEWART,
U. S. Assistant Engineer.

Capt. CARL F. PALFREY,
Corps of Engineers, U. S. A.,
Secretary Mississippi River Commission.

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Geographical positions north of Keokuk, Iowa.

[Referred to the Cairo Astronomical Post.]

Name of station.	Latitude. ° ′ ″	Seconds, in meters.	Longitude. ° ′ ″	Seconds, in meters.	Azimuth. ° ′ ″	Back azimuth. ° ′ ″	To station.	Distance. Meters.
△ Rapids	40 25 16.66	513.9	91 21 49.71	1,172.1	76 29 30.8	256 28 48.1	△ Lower Base	1,595.48
					112 04 46.9	292 03 50.8	△ Upper Base	2,203.55
					114 08 49.8	294 08 07.7	△ Pump House	2,061.07
△ Lower Base	40 25 04.58	141.2	91 22 55.52	1,297.3	157 46 05.6	337 45 52.0	△ Upper Base	1,297.33
					208 56 29.8	28 56 59.7	△ Church	2,244.34
					164 49 50.1	344 49 41.0	△ Pump House	1,259.64
△ Upper Base	40 25 43.51	1,342.1	91 23 16.34	385.3	169 05 47.7	349 05 40.7	△ Vineyard	1,340.49
					244 10 15.9	64 10 59.3	△ Church	1,751.80
					235 53 34.7	55 54 15.4	△ Mount Bell	1,788.39
△ Pump House	40 25 43.99	1,356.9	91 23 09.49	223.7				
△ Mount Bell	40 26 16.02	494.1	91 22 13.51	318.4				
△ Church	40 26 08.25	254.5	91 22 09.44	222.5	106 49 22.4	286 48 32.1	△ Vineyard	1,912.15
					183 51 12.9	3 51 16.5	△ Waggoner	1,911.96
△ Vineyard	40 26 26.18	807.5	91 23 27.10	638.8	195 46 40.8	15 46 59.6	△ Sandusky	2,511.74
					235 18 32.2	55 19 26.2	△ Waggoner	2,381.90
					280 14 35.7	100 15 23.4	△ Mount Bell	1,762.43
△ Waggoner	40 27 10.12	312.1	91 22 03.98	93.8	129 46 42.2	309 46 07.1	△ Sandusky	1,659.41
					198 17 40.5	18 17 54.8	△ Larry	1,656.66
△ Sandusky	40 27 44.54	1,373.8	91 22 58.11	1,369.1	196 32 12.7	16 32 31.5	△ Ballinger	2,394.25
					254 05 47.8	74 06 37.2	△ Larry	1,866.69
△ Larry	40 28 01.12	34.5	91 21 41.91	982.4	148 01 58.4	328 01 27.7	△ Ballinger	2,102.88
					192 47 31.9	12 47 47.4	△ Edmunds	2,540.09
△ Ballinger	40 28 58.95	1,817.3	91 22 29.18	687.2	173 01 38.8	353 01 33.0	△ Nashville	1,559.10
					247 31 19.0	67 32 05.2	△ Edmunds	1,813.42
△ Edmunds	40 29 21.42	660.7	91 21 18.03	424.6	114 37 28.2	294 36 36.8	△ Nashville	2,051.27
					171 35 00.6	351 34 46.7	△ Sheridan	3,448.35
△ Nashville	40 29 49.13	1,515.4	91 22 37.22	876.4	148 14 55.8	328 13 59.8	△ Institute	3,820.50
					207 59 51.0	28 00 28.5	△ Sheridan	2,895.74
					173 34 56.3	353 34 37.4	△ Catholic	6,121.47
△ Sheridan	40 31 12.02	370.8	91 21 39.47	929.1	101 36 46.4	281 35 13.4	△ Institute	3,440.12
					136 01 40.6	316 00 20.9	△ Nauvoo	4,157.28
△ Institute	40 31 34.44	1,062.3	91 24 02.63	61.9	143 21 46.9	323 20 43.2	△ Sand Ridge	3,865.24
					191 50 35.8	11 50 49.1	△ Nauvoo	2,349.65
					205 03 35.8	25 04 12.4	△ Catholic	3,129.25
△ Nauvoo	40 32 49.00	1,511.4	91 23 42.13	991.3	106 02 50.0	286 01 32.9	△ Sand Ridge	2,901.80
					201 45 04.2	21 45 23.4	△ Dobson	1,882.05
△ Sand Ridge	40 33 14.98	462.1	91 25 40.66	956.7	196 29 13.6	16 29 52.1	△ Macuta	4,908.61
					254 47 52.6	74 49 29.0	△ Dobson	3,612.21
					274 11 07.6		△ Catholic	3,641.79
△ Catholic	40 33 06.34	195.6	91 23 06.29	148.0				
△ Dobson	40 33 45.67	1,408.7	91 23 12.49	293.8	150 55 28.1	330 54 30.2	△ Macuta	4,302.79
					225 23 50.9	45 24 44.7	△ Sherman	2,729.74

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△ Macuta	40	35	47.57	1,467.3	91	24	41.41	973.8	227	01	50.8	47	04	04.7	△ Fort Madison	6,609.67
									294	32	38.8	114	34	30.4	△ Sherman	4,435.89
									259	15	31.4	79	19	26.4	△ Niota	8,640.36
△ Sherman	40	34	47.80	1,474.4	91	21	49.85	1,172.4	187	13	34.0	7	13	56.4	△ Fort Madison	6,398.21
Fort Madison	40	38	13.58	418.9	91	21	15.60	366.6	273	19	28.4	93	22	06.6	△ Penitentiary	5,721.03
									308	26	09.6	128	27	50.7	△ Niota	4,660.60
△ Niota	40	36	39.62	1,222.1	91	18	40.31	947.6	218	48	07.0	38	49	04.2	△ Penitentiary	2,290.61
									254	02	14.6	74	04	13.6	△ Appanoose	4,467.76
									168	30	38.0				△ St. Mary's Spire	
△ Penitentiary	40	38	02.75	84.8	91	17	12.57	295.4	220	59	21.7	41	00	20.3	△ Westcott	3,216.59
									300	53	51.0	120	54	52.9	△ Appanoose	2,602.44
△ Appanoose	40	37	19.41	598.7	91	15	37.56	882.9	178	08	28.0	358	08	24.6	△ Westcott	3,766.36
									262	30	55.7	82	34	01.6	△ Dallas	6,769.38
△ Westcott	40	39	21.45	661.6	91	15	42.76	1,004.6	229	40	35.7	49	45	55.8	△ Patterson	15,106.19
									229	10	47.0	49	13	15.4	△ Wever	7,068.17
									271	23	58.5	91	29	22.8	△ Lomax	11,698.14
									292	52	10.6	112	55	20.0	△ Dallas	7,416.95
△ Dallas	40	37	47.90	1,477.5	91	10	51.98	1,221.5	241	55	50.5	61	58	05.4	△ Lomax	5,509.20
									168	51	23.5	348	50	42.4	△ Wever	7,648.35
△ Lomax	40	39	11.89	366.8	91	07	25.06	588.9	127	48	26.8	307	45	30.9	△ Wever	8,019.54
									179	05	24.1	359	05	19.7	△ Patterson	10,062.44
									228	12	17.5	48	16	26.3	△ Carman	12,016.37
△ Wever	40	41	51.17	1,578.3	91	11	54.93	1,289.5								
△ Patterson	40	44	38.06	1,174.0	91	07	31.87	747.7	289	09	29.8	59	13	42.8	△ Ellison	10,558.41
									282	41	05.9	102	45	19.4	△ Carman	9,346.56
△ Carman	40	43	31.34	906.7	91	01	03.33	78.2	139	39	51.2	319	36	46.9	△ Burlington	10,284.16
									179	39	51.9	359	39	50.7	△ Ellison	7,465.68
△ Ellison	40	47	33.36	1,029.0	91	01	05.19	121.7	93	14	03.0	273	10	58.7	△ Burlington	6,623.41
									153	51	57.2	333	49	36.4	△ Sater	11,438.98
									214	06	30.4	34	08	52.4	△ Gladstone	9,071.91
									61	12	57.7	241	09	13.8	△ B. M. Pat	
△ B. M. Pat	40	45	09.98	307.8	91	06	48.04	1,127.0	290	35	02.8	110	38	47.8	△ Carman	8,641.48
△ Burlington	40	47	45.38	1,399.8	91	05	47.27	1,108.1	188	59	16.5	9	00	00.2	△ Sater	10,020.30
△ Gladstone	40	51	36.81	1,135.4	90	57	27.99	655.5	156	45	58.0	336	42	56.5	△ Kingston	16,414.65
									203	43	59.8	23	46	22.0	△ Henderson	12,616.01
									183	36	14.9	3	36	29.1	△ Oquawka Spire	8,055.65
△ Sater	40	53	06.23	192.2	91	04	40.41	946.1	239	54	02.8	60	01	07.8	△ Henderson	17,516.48
									285	11	53.3	105	16	36.3	△ Gladstone	10,494.66
△ Henderson	40	57	51.14	1,577.4	90	53	50.80	1,198.8	107	02	55.9	286	57	31.8	△ Kingston	12,081.35
									183	50	07.0	3	50	22.1	△ Bald Bluff	8,017.16
									52	31	38.5	232	29	25.4	△ Oquawka Spire	5,763.04
△ Oquawka Spire	40	55	57.73	1,771.4	90	57	06.34	148.8								
△ Kingston	40	59	45.68	1,409.0	91	02	05.02	117	174	01	55.4	354	01	09.8	△ Toolsboro	15,527.14
									249	35	34.4	69	41	13.8	△ Bald Bluff	12,889.85
									315	12	31.8				△ Oquawka Spire	
△ Bald Bluff	42	02	11.05	340.8	90	58	27.83	650.1	128	44	03.8	308	37	38.4	△ Toolsboro	17,533.62
									169	05	44.8	349	04	13.8	△ East Base	17,058.80
									149	25	58.8	329	21	49.4	△ New Boston Spire	17,350.74
△ Toolsboro	41	08	06.28	193.7	91	03	14.23	331.9	147	11	08.9	327	07	59.1	△ Louisa	•12,974.07
									205	18	52.6	25	21	36.5	△ Sturgeon	13,548.47
									240	50	47.9	61	01	42.7	△ East Base	11,942.05
									230	37	15.1	50	39	31.9	△ New Boston Spire	6,269.48

Geographical positions north of Keokuk, Iowa—Continued.

[Referred to the Cairo Astronomical Post.]

Name of station.	Latitude.			Seconds in meters.	Longitude.			Seconds in meters.	Azimuth.			Back azimuth.			To station.	Distance.
	°	′	″		°	′	″		°	′	″	°	′	″		Meters.
△ East Base	41	11	14.03	432.8	90	55	46.29	1,078.7	144	18	25.9	324	16	14.7	△ Sturgeon	7,947.67
									73	21	18.1	253	18	49.1	△ West Base	5,506.00
									72	02	40.7				△ New Boston Spire	5,882.55
△ Sturgeon	41	14	43.22	1,333.4	90	59	05.44	126.7	4	30	36.2	184	30	18.2	△ West Base	8,057.37
									84	03	51.3	263	57	48.4	△ Louisa	12,894.22
△ West Base	41	10	22.85	704.6	90	59	32.62	760.5								
△ Louisa	41	13	59.63	1,839.6	91	08	16.13	375.7								
△ New Boston Spire	41	10	15.18	468.3	90	59	46.35	1,080.5								

Geographical positions of tertiary points north of Keokuk, Iowa.

[Referred to the Cairo Astronomical Post.]

Name of point.	Latitude. ° ′ ″	Seconds, in meters.	Longitude. ° ′ ″	Seconds, in meters.	Azimuth. ° ′ ″	Back azimuth. ° ′ ″	To station.	Distance. Meters.
⊡ $\frac{1}{2}{}^{2}$	40 26 32.82	1,012.3	91 22 19.79	466.4	85 26 03	265 25 21	⊡ $\frac{1}{3}{}^{2}$	1,514.0
					41 13 53	221 13 16	△ Upper Base	2,022.4
					82 39 01		△ Vineyard	1,599.4
⊡ $\frac{1}{3}{}^{2}$	40 26 28.91	891.7	91 23 23.82	561.4	265 25 21	85 26 03	⊡ $\frac{1}{2}{}^{2}$	1,514.0
					289 58 08	109 58 56	△ Church	1,865.6
					235 56 53		△ Waggoner	2,270.9
⊡ $\frac{1}{2}{}^{3}$	40 29 08.12	250.5	91 21 21.58	506.4	84 26 30	264 25 50	⊡ $\frac{1}{3}{}^{3}$	1,470.8
					79 56 17	259 55 33	△ Ballinger	1,617.0
					125 23 13	305 22 24	△ Nashville	2,184.7
⊡ $\frac{1}{3}{}^{3}$	40 29 03.50	108.0	91 22 24.02	565.7	250 25 04	70 25 47	△ Edmunds	1,649.6
					332 43 29	152 43 56	△ Larry	2,165.0
⊡ $\frac{1}{2}{}^{4}$	40 31 46.72	1,441.1	91 22 20.91	492.1	59 22 55	239 22 19	⊡ $\frac{1}{3}{}^{4}$	1,508.2
					6 02 34	186 02 23	△ Nashville	3,647.2
					81 01 32	261 00 26	△ Institute	2,423.9
⊡ $\frac{1}{3}{}^{4}$	40 31 21.81	672.7	91 23 16.06	378.1	277 33 22	97 34 25	△ Sheridan	2,293.7
					184 04 19		Nauvoo Spire[1]	
⊡ $\frac{1}{2}{}^{5}$	40 33 08.39	258.8	91 24 00.20	4.7	103 35 48	283 35 14	⊡ $\frac{1}{3}{}^{5}$	1,265.2
					224 18 17	44 18 48	△ Dobson	1,607.0
					272 51 02		Nauvoo Spire	
⊡ $\frac{1}{3}{}^{5}$	40 33 18.03	556.1	91 24 52.47	1,234.6	250 03 55	70 05 02	△ Dobson	2,501.8
					298 24 45	118 25 31	△ Nauvoo	1,881.5
					278 12 04		Nauvoo Spire	
⊡ $\frac{1}{3}{}^{6}$	40 34 54.96	1,695.2	91 21 50.84	1,195.7	128 38 00	308 37 42	⊡ $\frac{1}{3}{}^{6}$	862.2
					41 56 55	221 56 02	△ Dobson	2,873.8
⊡ $\frac{1}{2}{}^{6}$	40 35 12.42	383.1	91 22 19.47	457.9	317 28 12	137 28 31	△ Sherman	1,030.4
					24 59 34	204 58 59	△ Dobson	2,952.2
					128 38 32	208 38 16	⊡ $\frac{1}{4}{}^{6}$	740.0
⊡ $\frac{1}{4}{}^{6}$	40 35 27.40	845.1	91 22 44.05	1,035.9				
◬ Macuta	40 35 47.57	1,467.3	91 24 41.41	973.8	335 42 30		Nauvoo Spire[1]	
⊡ $\frac{1}{1}{}^{7}$	40 36 43.40	1,338.7	91 18 39.14	920.0	155 46 00	335 45 48	⊡ $\frac{1}{2}{}^{7}$	1,026.5
					155 54 00	335 53 37	⊡ $\frac{1}{3}{}^{7}$	1,998.7
					211 59 50	32 00 29	△ 2	2,657.2
⊡ $\frac{1}{2}{}^{7}$	40 37 13.74	423.8	91 18 57.07	1,341.5	156 02 18	336 02 07	⊡ $\frac{1}{3}{}^{7}$	972.3
					339 28 45	159 28 56	△ Niota	1,123.8
					234 14 08	54 14 59	△ 2	2,254.3
					175 33 56	355 33 53	△ St. Mary's Spire	1,433.3
⊡ $\frac{1}{3}{}^{7}$	40 37 42.55	1,312.4	91 19 13.88	326.2	207 46 53		do	
△ 2[5]	40 37 56.45	1,741.2	91 17 39.24	922.0	93 18 11	273 17 17	do	1,942.8
					31 12 49	211 12 11	△ Niota	2,770.7
△ St. Mary's Spire[4]	40 38 00.08	2.5	19 19 02.77	65.1				

[1] Nauvoo Spire or △ Catholic is the very high spire of Catholic Church at Nauvoo, Ill.

[4] △ St. Mary's Spire is spire of St. Mary's Catholic Church, Fort Madison, Iowa.

[5] △2 is oak stake on down-stream side reservoir hill, Fort Madison, Iowa.

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Geographical positions of tertiary points north of Keokuk, Iowa—Continued.

[Referred to the Cairo Astronomical Post.]

Name of point.	Latitude. ° ′ ″	Seconds, in meters.	Longitude. ° ′ ″	Seconds, in meters.	Azimuth. ° ′ ″	Back azimuth. ° ′ ″	To station.	Distance.
								Meters.
⊡ 118/2	40 37 41.62	1,283.8	91 16 02.14	50.3	155 05 31	335 05 14	⊡ 118/3	1,449.8
					319 51 12	139 51 28	△ Appanooce	896.2
					111 29 47	291 29 01	△ Penitentiary	1,778.7
⊡ 118/5	40 38 24.25	748.0	91 16 28.12	660.8	43 55 24	223 53 58	△ Niota	4,479.6
⊡ 118/1	40 37 09.58	295.5	91 12 50.89	1,196.2	176 41 56	356 41 54	⊡ 118/1	1,567.5
					176 19 50	356 19 46	⊡ 118/2	2,797.1
					192 55 48		Mill Chimney[1]	
⊡ 118/2	40 38 00.31	9.6	91 12 54.73	1,286.2	175 51 37	355 51 35	⊡ 118/3	1,229.7
					122 23 07	302 21 18	△ Westcott	4,674.6
					277 33 00	97 34 20	△ Dallas	2,910.1
					280 58 20		Mill Chimney	
⊡ 118/3	40 38 40.07	1,236.0	91 12 58.51	1,374.7	175 51 07	355 51 05	⊡ 118/4	807.0
					298 24 50	118 26 12	△ Dallas	3,380.9
⊡ 119/4	40 39 06.17	190.3	91 13 00.99	23.3				
⊡ 120/1	40 38 26.94	831.0	91 09 18.19	427.5	153 59 48	333 59 37	⊡ 120/2	877.9
					153 56 40	333 56 09	⊡ 120/3	2,569.8
					61 21 18	241 20 17	△ Dallas	2,511.4
					75 40 20		Mill Chimney	
					65 01 40		Church Bell	
⊡ 120/2	40 38 52.52	1,620.0	91 09 34.57	812.2	153 54 44	333 54 28	⊡ 120/3	1,692.0
⊡ 120/3	40 39 41.78	1,288.7	91 10 06.24	146.6	153 54 18	333 54 04	⊡ 120/4	764.8
					17 00 41	197 00 11	△ Dallas	3,673.4
⊡ 120/4	40 40 04.05	124.9	91 10 20.56	482.9				
⊡ 121/1	40 40 26.95	831.3	91 06 16.04	376.8	35 00 52	215 00 07	△ Lomax	2,825.8
⊡ 121/2	40 40 37.89	1,168.7	91 06 41.96	985.4	112 56 10	292 55 36	⊡ 121/3	1,320.4
⊡ 121/3	40 40 54.56	1,683.0	91 07 33.74	792.3	112 44 39	292 44 25	⊡ 121/4	554.5
					356 18 45	176 18 51	△ Lomax	3,172.9
⊡ 121/4	40 41 01.52	46.9	91 07 55.52	1,303.8				
⊡ 122/1	40 43 41.35	1,275.5	91 05 54.56	1,280.2	88 59 46	268 59 23	⊡ 122/2	818.3
⊡ 122/2	40 43 40.88	1,261.0	91 06 29.44	690.8	88 59 18	268 58 45	⊡ 122/3	1,015.3
					88 59 00	268 58 09	⊡ 122/4	1,845.3
					170 58 47	350 58 35	△ B. M. Pat[2]	2,782.5
⊡ 122/3	40 43 40.30	1,243.1	91 07 12.70	298.0	88 58 04	268 57 41	⊡ 122/4	830.0
⊡ 122/4	40 43 39.81	1,228.0	91 07 48.06	1,127.7	206 51 12	26 51 51	△ B. M. Pat[2]	3,117.3
⊡ 123/1	40 45 42.44	1,309.1	91 05 13.82	324.1	106 26 16	286 26 01	⊡ 123/2	560.0
⊡ 123/2	40 45 47.57	1,467.4	91 05 36.72	861.2	106 34 04	286 33 45	⊡ 123/3	697.0
					178 43 44		(1891) Center of draw Burlington Bridge.	
⊡ 123/3	40 45 54.01	1,666.0	91 06 05.20	122.0	246 26 07	66 29 23	△ Ellison	7,673.6
					301 49 47	121 53 04	△ Carman	8,838.5
⊡ 124/1	40 48 43.82	1,351.7	91 05 03.30	77.3	102 58 55	282 58 38	⊡ 124/1	630.9

⊡ 124	40	48	48.41	1,493.3	91	05	29.53	692.0	103	10	50	283	10	30	⊡ 124	746.4
									66	43	44	246	43	02	Church spire	1,628.8
									74	21	17	254	20	53	Court-house Dome	884.3
⊡ 124	40	48	53.92	1,663.3	91	06	00.54	12.7	193	33	11	13	34	03	△ Sater	8,006.0
									16	58	35	196	58	32	Court-house Dome	427.3
△ Church Spire[6]	40	48	27.54	849.5	91	06	33.37	782.3								
△ Court-house Dome[7]	40	48	40.67	1,254.6	91	06	05.86	137.8								
⊡ 125	40	50	25.54	787.9	91	03	13.31	311.8	120	08	40	300	08	24	⊡ 125	626.0
⊡ 125	40	50	35.73	1,102.2	91	03	36.42	853.1	119	45	18	299	45	00	⊡ 125	568.4
⊡ 125	40	50	44.87	1,384.1	91	03	57.48	1,346.5	119	33	38	299	33	14	⊡ 125	988.6
⊡ 125	40	51	00.68	21.0	91	04	34.19	800.8								
⊡ 126	40	52	24.14	744.7	91	01	19.24	450.6	127	19	14	307	18	56	⊡ 126	814.0
⊡ 126	40	52	40.14	1,238.2	91	01	46.89	1,097.8	127	32	16	307	31	55	⊡ 126	947.6
⊡ 126	40	52	58.86	1,815.7	91	02	18.98	444.3	127	49	45	307	49	30	⊡ 126	666.8
⊡ 126	40	53	12.12	373.8	91	02	41.48	971.1								
⊡ 127	40	54	13.24	408.4	90	58	40.22	941.5	122	49	38	302	49	24	⊡ 127	587.0
⊡ 127	40	54	23.55	726.5	90	59	01.30	30.4	122	45	42	302	45	14	⊡ 127	1,210.3
									122	45	19	302	44	33	⊡ 127	1,945.3
⊡ 127	40	54	44.78	1,381.3	91	59	44.78	1,047.9	122	44	12	302	43	55	⊡ 127	735.0
⊡ 127	40	54	57.66	1,778.6	91	00	11.20	262.1								
⊡ 128	40	56	39.43	1,216.8	90	57	11.47	268.3	111	19	31	291	19	04	⊡ 128	1,052.0
									195	00	26	15	00	58	⊡ 128	4,387.3
									244	44	24	64	46	36	△ Henderson	5,187.5
⊡ 128	40	56	51.83	1,596.8	90	57	53.86	1,248.1	111	21	55	291	21	37	⊡ 128	674.0
									326	44	48	146	45	19	△ Oquawka Spire[8]	2,006.4
⊡ 128	40	56	59.79	1,844.4	90	58	20.20	472.5								
⊡ 128	40	58	56.80	1,752.1	90	56	22.87	584.6	132	29	26	312	29	01	⊡ 129	1,198.4
									214	18	07	34	20	02	⊡ Bald Bluff	7,255.2
									299	39	38	119	41	18	△ Henderson	4,091.1
⊡ 129	40	59	23.04	710.8	90	57	00.68	15.9	105	12	11	285	11	36	△ 129	1,296.8
⊡ 129	40	59	34.06	1,050.7	90	57	54.22	1,267.2	104	55	59	284	55	41	⊡ 129	661.0
⊡ 129	41	59	39.59	1,221.3	90	58	21.55	503.8								
⊡ 130	41	02	13.60	419.6	90	55	54.12	1,264.2	86	49	47	266	49	28	⊡ 130	693.0
⊡ 130	41	02	12.35	381.0	90	56	23.74	554.6	87	52	44	267	52	22	⊡ 130	790.7
									9	23	12	189	22	48	⊡ 130	5,293.4
⊡ 130	41	02	11.40	351.7	90	56	57.56	1,344.6	87	51	57	267	51	36	⊡ 130	752.0
⊡ 130	41	02	10.50	323.9	90	57	29.73	694.5								
⊡ 131	41	04	35.02	1,080.4	90	56	23.45	547.3	86	10	54	266	10	18	⊡ 131	1,296.9
									317	39	14	137	41	06	△ Bald Bluff	6,090.8
⊡ 131	41	04	34.22	1,055.7	90	57	18.88	440.7	84	35	13	264	34	53	⊡ 131	704.5
									309	16	53	129	19	21	△ Bald Bluff	6,972.3
									187	10	31	7	10	43	△ 24=center of draw span, I. C. R. R.	3,329.1
⊡ 131	41	04	32.06	989.1	90	57	48.90	1,141.4								
⊡ 132	41	07	27.31	842.5	90	57	25.06	584.6	77	11	16	257	10	56	⊡ 132	735.8
⊡ 132	41	07	22.02	679.3	90	57	55.82	1,302.3	76	56	46	256	56	25	⊡ 132	749.6
⊡ 132	41	07	16.53	509.9	90	58	27.12	632.7	77	28	25	257	28	04	⊡ 132	755.5
⊡ 132	41	07	11.22	346.1	90	58	58.73	1,870.2								

[1] Mill Chimney is prominent smoke stack at Dallas City, Ill.

[5] △ B. M. Pat. is B. M. pipe and △ tile on promontory 4 miles below Burlington, Iowa.

[6] Church Spire is finial of Catholic Church at Burlington, Iowa.

[7] Court-house Dome is finial of Court-house Dome at Burlington, Iowa.

[8] Oquawka Spire is finial of Methodist Church spire in Oquawka, Ill.

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Geographical positions of tertiary points north of Keokuk, Iowa—Continued.

[Referred to the Cairo Astronomical Post.]

Name of point.	Latitude. °	′	″	Seconds, in meters.	Longitude. °	′	″	Seconds, in meters.	Azimuth. °	′	″	Back azimuth. °	′	″	To station.	Distance. Meters.
△ 24	41	06	21.29	656.8	90	57	01.06	24.7								
⊡ 133/1	41	09	48.70	1,502.4	90	58	54.75	1,276.4	52	04	20	232	04	02	⊡ 133/2	790.2
⊡ 133/2	41	09	32.96	1,016.8	90	59	21.48	500.8	52	43	28	232	43	02	⊡ 133	929.0
									170	25	36	350	25	29	△ West Base	1,560.7
									156	00	50	336	00	34	⊡ N. Boston Spire*	397.9
⊡ 133/3	41	09	14.72	454.1	90	59	53.18	1,240.1	52	43	29	232	48	09	⊡ 133/3	892.4
									184	53	17	4	58	22	△ N. Boston Spire	1,872.0
⊡ 133/4	41	08	57.19	1,764.3	91	00	23.64	551.3								
⊡ 134/1	41	10	45.47	1,402.8	91	02	09.16	213.5	36	08	25	216	03	11	⊡ 134/2	813.0
⊡ 134/2	41	10	24.16	745.3	91	02	29.68	691.9	36	06	42	216	06	27	⊡ 134/3	885.1
⊡ 134/3	41	10	00.99	30.5	91	02	52.06	1,218.6	35	57	56	215	57	40	⊡ 134/4	970.0
⊡ 134/4	41	09	35.54	1,096.4	91	03	16.49	384.4								
⊡ 135/1	41	12	46.21	1,425.6	91	03	44.08	1,026.9	54	14	33	234	14	14	⊡ 135/2	842.0
⊡ 135/2	41	12	30.25	933.2	91	04	13.41	312.3	54	16	55	234	16	43	⊡ 135/3	526.5
									116	01	10	295	58	30	△ Lomax	6,290.4
⊡ 135/3	41	12	20.29	625.9	91	04	31.76	740.0	54	18	03	234	17	38	⊡ 135/4	1,091.7
⊡ 135/4	41	11	59.64	1,839.9	91	05	09.81	228.6								

* ∧ N. Boston Spire is center of square tower or spire of Methodist Church in New Boston, Ill.

DESCRIPTIONS OF SECONDARY TRIANGULATION STATIONS FROM KEOKUK, IOWA, TO PORT LOUISA, IOWA.

△ Church is on Illinois side, on bluff in timber on land owned by Dr. Kennal. Station is about 250 meters south of Mount Bell schoolhouse and 100 meters below a very prominent ravine. A road leaves river road at mouth of ravine and runs on upper side of ravine past the schoolhouse. A house stands near river bank on lower side of ravine, occupied by J. H. Brown. A small barn stands at foot of bluff, on back side of cultivated field, directly in front of station. Geodetic point is center of copper bolt in vitrified tile 18 inches square and 4 inches thick; 3 feet under ground. Tile is surmounted by a 3-inch pipe 4 feet long, with cast iron cap. Station is 150 meters back of crest of bluff and is about opposite dry dock at middle lock, Des Moines Rapids Canal.

△ Pump House is center of iron smokestack in center of small pump house at upper end of dry dock at middle lock of Des Moines Rapids Canal. Pump house stands on embankment between canal and river.

△ Mount Bell is the center of top of cupola of small frame schoolhouse on side of bluffs on Illinois side; opposite and a little above middle lock, Des Moines Rapids Canal.

△ Sandusky is the center of a copper bolt leaded into coping stone on east side of wall and over south sluice gate of waste gate, in dam between Des Moines Rapids Canal and River; opposite Sandusky Station on St. Louis, Keokuk and Northwestern Railroad. A house stands above and on dam.

△ Waggoner is on Illinois side, on first bluff below mouth of Waggoners Creek. Station is on cleared land, 17 meters south of wire fence running back from crest of bluff, and 45 meters back from crest of bluff. A wagon road runs back from river above creek and below station. Geodetic point marked by center of copper bolt leaded in tile 18 by 18 by 4 inches, buried 3 feet below surface and surmounted by a 3-inch iron pipe.

△ Vineyard is on bluffs on Iowa side, three-fourths of a mile above middle lock of Des Moines Rapids Canal. It is in a vineyard 20 feet back from crest of bluffs. An ice house stands on bank of canal 500 feet above station. A hedge fence runs up the hill from the railroad 300 feet below station and on lower edge of vineyard.

△ Institute is on Iowa side on bluffs on land owned by Park Bluff Association. Station is just north of narrow lane running east and west, and 200 meters back of crest of bluff. Station is marked by a 4 by 18 by 18 inch vitrified tile, with copper bolt leaded in the center, surmounted by a 4-inch iron pipe. Station is 300 meters below summer cottages on crest of bluff. A deep ravine is between houses and station.

△ Ballinger is at top of bluff on Iowa side, 50 feet back from crest, and one-half mile above M. P. 37 on St. Louis, Keokuk and Northwestern Railroad. Station stands on a narrow ridge running parallel with the river. Geodetic point marked by copper bolt leaded into vitrified tile 4 by 18 by 18 inches, buried 3 feet under ground and surmounted by a 4-inch iron pipe.

△ Larry is on highest point of bluff just above mouth of Larrys Creek, on Illinois side of river. Top of bluff is cultivated, slopes are timbered 15 meters from wire fence running along crest of bluff. Small one-story white frame house stands 200 meters above. Geodetic point is marked by a copper bolt leaded into a 4 by 18 by 18 inches vitrified tile, 3 feet under ground, surmounted by a 4-inch iron pipe.

△ Edmunds is on crest of low bluff on Illinois side, one-half mile below and opposite upper lock Des Moines Rapids Canal. Station stands on point of small knoll 38 meters in front of hedge fence and 45 meters below corner of fence. It is about 400 meters below where bottom land runs out into river to a point about 600 meters below Sonora Landing. Geodetic point is marked by a center of copper bolt leaded into a 4 by 18 by 18 inch vitrified tile, buried 2½ feet in ground, surmounted by a 4-inch iron pipe.

△ Nashville is on Iowa side, on top of bluff about 400 meters back of the town of Nashville. It is at a wire fence running north and south and on highest part of ridge between two deep gullies running to river. A one and a half-story frame house stands 300 feet back of and a little above the station. Geodetic point marked by center of copper bolt leaded into a 4 by 18 by 18 inch tile, 2½ feet under ground, surmounted by a 4-inch pipe.

△ Sheridan is on Illinois side, on hill in cultivated field just above a hedge running east and west. Station is at northeast corner of orchard and about 400 meters above Sheridan Creek and same distance back of river. Geodetic point marked by copper bolt in tile, surmounted with 4-inch pipe.

△ Dobson is on Illinois side, at top of bluff near crest, and 150 meters from the river. It is on upper side of point above Nauvoo, 600 meters above Nauvoo Landing. Nearly in direct line of N. and S. street prolonged and north of a two-story brick house, 32 meters north of fence corner at upper side of vineyard. Geodetic point marked by copper bolt in square tile and iron pipe projecting out of ground 8 inches.

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△ Nauvoo is on east side of the west, north, and south street that runsnearly across the bottom land in front of the town of Nauvoo, Ills. A large farm of small fruit lies west of street to river. A fruit barn stands on west line of street opposite station. A two-story brick house stands east of station 200 feet. South end of street at river is just above slaughterhouse. Geodetic point marked by copper bolt in tile, surmounted by iron pipe.

△ Sand Ridge is on Iowa side and about 1¼ miles above Montrose, on a sand ridge on west side of wagon road, 10 feet inside of fence. Railroad adjoining wagon road on east side. Station is 300 meters below Milepost 30, and about 300 meters above a small shanty near corner of hedge fence. Geodetic point marked by usual copper bolt in tile and iron pipe.

△ Macuta is on Iowa side of river, 5¼ miles below Fort Madison, 4 feet north of fence on north side of right of way of Chicago, Santa Fe and California Railway, 200 feet northeast of southwest switch stand of siding, about 450 meters above (northeast) Howe truss bridge over Devils Creek, 70 meters (distance paced) northeast along railway fence from a north and south fence. Geodetic point marked by a copper bolt in usual tile, surmounted by iron pipe projecting 4 inches above ground.

△ Fort Madison is on Iowa side, on top of bluff, just above north and south fence about 1¼ miles back of river. Fence runs across bottom, just below foundry shops of Chicago, Santa Fe and California railway. A two-story brick schoolhouse stands directly south of station on street on which street cars run to Fort Madison. Station is about 2 miles below the town. Geodetic point marked by copper bolt in flat tile and surmounted by iron pipe.

△ Sherman is on Illinois side of river, 2¼ miles above Nauvoo, on bluffs in timber, about 200 meters below where steep rocky bank of river ends and flat bar, partly covered with large willows, begins, back of and a little below the remains of an old foundation wall standing on river bank. Station stands on a projecting point in ridge 75 meters in front of fence at edge of clearing. Geodetic point marked by usual copper bolt in tile, surmounted by iron pipe. Several trees 10 to 12 inches diameter were cut around station. It is about 100 meters below B. M. $\frac{1}{2}^{6}$ which stands on side of road at foot of hill. A house stands on crest of bluff about 400 meters above.

△ Penitentiaryis on Iowa side on crest of steep bluff above ravine just above new reservoir of Fort Madison city waterworks. Station is on narrow ridge parallel with river and 75 meters above end of ridge. A two-story brick house stands 300 meters back of and a little below station, which is 10 feet from crest of bluff on river side. Geodetic point marked by copper bolt in tile, surmounted by iron pipe projecting 14 inches out of ground. About 1 mile above Fort Madison railroad bridge.

△ Niota is on Illinois side of river, on top of bluff, about 1 mile below Chicago, Santa Fé and California Railway bridge at Fort Madison. It is 6 meters back of crest of bluff on a small mound, about 100 meters below where bluffs turn back from river. It is almost directly opposite railroad depots in Fort Madison. Bluffs timbered. It is in front of and a little above a fence corner at northwest corner of clearing. Geodetic point marked by usual copper bolt in tile, surmounted by iron pipe projecting 8 inches out of ground. Line cut through timber to Appanooce.

△ Appanooce is on Illinois side of river, in cultivated field, 20 meters above telegraph pole on which is fastened two hundred and thirty-fourth mile board Chicago, Santa Fe and California Railway, and 30 meters west of west right-of-way fence. Road crosses railroad about 300 meters above station. It is about 2 miles above Niota, Ill. Geodetic point marked by usual copper bolt in tile, surmounted by iron pipe projecting above ground 1 foot. It is about three-fourths mile back from river bank.

△ Lomax is on Illinois side, on top bluffs about 800 meters above Milepost 13, Carthage branch of Chicago, Burlington and Quincy Railroad, 2¼ miles above Dallas City. Station is on crest of bluff back of small field used for pasture, 250 meters above house. It is on the upper one of three small ridges which form the point on the bluff line. Geodetic point marked by usual copper bolt in square tile, surmounted by iron pipe projecting 4 inches above ground.

△ Dallas is on Illinois side, on bluff about three-fourths mile below Dallas City. Station is 6 meters south of picket fence running down the bluff. A dry creek running out of small ravine just above station runs through Bridge 320 on Chicago, Santa Fé and California Railway. Geodetic point marked by small copper bolt in tile, surmounted by iron pipe projecting 10 inches above ground.

△ Westcott is on Iowa side, on top of bluff, about one-fourth mile below (toward Fort Madison) Milepost 15, St. Louis, Keokuk and Northwestern Railroad. In corner of fence at jog in road. A two-story brick house stands on crest of bluff where road goes down bluff about 300 meters above station. Geodetic point marked by usual copper bolt in tile, surmounted by iron pipe projecting 10 inches above ground. Line cut to penitentiary △.

△ Carman is on Illinois side, on bare bluff, on land owned by James Perry, 3 miles

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east of Carman. An east and west road crossing the railroad ends at fence at foot of hill, 150 meters north of station. A hedge fence runs north and south 40 meters west of station. An east and west board fence is 60 meters south of station. A two-story white frame house stands 200 meters above station on hill. Station is on small knoll above gully, and is not on highest part of bluff. Geodetic point is marked by usual copper bolt in tile, surmounted by iron pipe projecting 2 inches above ground.

◬ Wever is on Iowa side in bottom, about 2 miles southeast of town of Wever, on land owned by George Tucker. It is 200 meters east of road, in pasture 1¼ meters east of fence. A small one-story frame house stands on west side of road nearly west of station. Schoolhouse stands on road 200 meters south of house. Geodetic point marked by usual copper bolt in tile, surmounted by iron pipe.

◬ Patterson is on Iowa side, on crest of bluffs, 75 meters above Milepost 5, St. Louis, Keokuk and Northwestern Railroad. At wire fence running along bluff. A house stands opposite the milepost at foot of hill. Geodetic point marked by usual copper bolt in tile, surmounted by iron pipe projecting 8 inches above ground.

◬ Burlington is on crest of bluff in South Burlington, on line of fence on north line of alley south of Polk street, and 2 meters from end of fence, about 200 meters below bridge. Geodetic point marked by usual copper bolt in tile.

◬ Sater is on Iowa side on crest of bluff about 6 miles above Burlington. A one-and-a-half story frame house stands on east side of road about 100 meters south of station. Bluff is partly wooded. Road runs up bluff 800 meters south of station. House at foot of bluff is painted dark red with white trimmings and is not occupied. Geodetic point marked by usual copper bolt in tile, surmounted by iron pipe projecting 14 inches above ground.

◬ Gladstone is on bluff south of town of Gladstone, Ill. Old distillery stands 200 meters southwest of station at foot of bluff. Station is in pasture 300 meters east of main street of town running south from depot, and 100 meters south of south street of town, 10 meters north of fence. Geodetic point marked by copper bolt in tile, surmounted by iron pipe projecting 2 inches out of ground.

◬ Ellison is on Illinois side, in bottom opposite lower part of Burlington, about 3 miles back from river and one-half mile below Ellison Creek. It is on sand ridge 75 meters south of east and west road and 400 meters east of where Carman and Burlington road turns south. A house and large red barn stand 150 meters north of station. Geodetic point marked as usual.

◬ Henderson is on Illinois side on bluff 3 miles above Oquawka station. Is on projecting point of bluff near where Henderson river comes to bluff. A house stands at foot of bluff 1,200 meters south and one on bluff 300 meters directly back of station. Geodetic point marked by copper bolt in tile, surmounted by pipe projecting 8 inches out of ground. Station on land owned by Mr. H. P. Burghet.

◬ East base is on south side of track of Chicago, Burlington and Quincy Railroad at foot of low embankment and three telegraph poles west of crossing just west of milepost No. 47. Geodetic point marked by usual copper bolt in tile, surmounted by iron pipe.

Elevation of ◬ east base, 598.28.

◬ West base is on north side of right of way of Chicago, Burlington and Quincy Railroad, 3 meters south of right-of-way fence, 300 meters east of east road crossing in town of New Boston. On highest part of ground through which railroad has been cut. Geodetic point is usual copper bolt in tile with pipe projecting 8 inches.

Elevation of ◬ west base, 583.96.

New Boston base line was measured along south side of track of Chicago, Burlington and Quincy Railroad running east from New Boston.

◬ Sturgeon is on Illinois side on top of bluff 5 miles north of New Boston. It is nearly on line with the north and south main road from New Boston to Muscatine. A small white house stands on bluff side of road, 100 meters south of station. It is 12 meters south of fence running up bluffs at south end of orchard.

◬ Bald Bluff is on highest point of "Bold Bluff" on Illinois side, 6¼ miles southeast of Keithsburg. Bluff is very prominent from all directions. Geodetic point is usual copper bolt in tile, surmounted by iron pipe projecting 8 inches. Station is on land owned by H. P. Burghet (?).

◬ Kingston is on Iowa side about 7 miles south of Oakville. Station is on very prominent bluff. Road from Toolsboro to Burlington runs along foot of bluff. Small white frame house stands on bluff side of road a little north of station. A road runs up gully and onto bluffs about 400 meters north of station. Schoolhouse stands short distance north of fork in road. Station is on cultivated ground, 75 meters south of wire fence running down bluff to near house. Bluffs timbered 300 meters below station. Line cut to station Gladstone. Geodetic point marked by usual copper bolt in tile, surmounted by iron pipe projecting 14 inches above ground.

◬ Toolsboro is on crest of bluffs, about three-fourths mile below Toolsboro, Iowa, on land owned by Mrs. Parsons. It is about 100 meters in front of road, in timber. Mrs. Parson's house, a two-story white frame, stands on west side of road, about 300

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meters above (north) station. Station stands on extreme edge of hill and on a little projecting point. Geodetic point is marked by usual copper bolt in tile, surmounted by iron pipe projecting 8 inches above ground.

Ⓐ Louisa is on crest of bluffs on Iowa side, nearly due west of Port Louisa. Station is 2 meters north of fence on north side of small cemetery known as "Cameron Cemetery," and two meters east of north and south fence running along crest of bluffs on land of Mr. Cameron. Road comes up bluff just south of cemetery. Geopetic point marked by usual copper bolt in tile, surmounted by iron pipe projecting 15 inches above ground.

△ B. M. Pat. is at point of preliminary location of Ⓐ Patterson. As it could not be used as a secondary station, the △ tile was left in position and a B. M. cap was placed on top of pipe. It is in field 2 meters north of hedge fence, on hill near top, abreast the 4-mile post Chicago, Burlington and Quincy Railroad. A two-story stone house, with no roof, is on slope of hill about 100 meters from stone.

The name is chosen to prevent confusion, as a secondary station, "Patterson," was chosen 1424.4 meters below on the bluffs.

APPENDIX 4 B.

REPORT OF ASSISTANT ENGINEER O. W. FERGUSON, ON FIELD WORK AND REDUCTION OF PRECISE LEVELS FROM ST. PAUL, MINNESOTA, TO SAVANNA, ILLINOIS, WITH TABULATED RESULTS AND DESCRIPTIONS OF BENCH MARKS.

OFFICE OF THE SECRETARY,
St. Louis, Mo., March 12, 1892.

SIR: I have the honor to present the following report on precise-level work from St. Paul, Minn., to Savanna, Ill.:

The double precise-level party for this work was organized at this office on April 25, 1891, and consisted of O. W. Ferguson, assistant in charge; L. M. Mann, assistant engineer; F. B. Williams, recorder; Irving W. Durfee, recorder; John P. Baker, rodman; L. B. McKeen, rodman; J. A. Warrick, rodman; R. J. Dickinson, rodman; Frank VanNess, foreman; E. J. Burgess, axman; H. M. Conradt, axman; H. M. Willson, axman; J. H. Tyner, cook; T. M. Brennan, steward.

The United States survey boat *Kentucky* had been assigned to this work and was lying at the foot of Barton street. Pursuant to orders from Chief Assistant Ockerson, all hands were on board ready to start up the river under tow by the United States steamer *Patrol* at 11 o'clock on April 25, 1891. Owing to the large number of tile and iron pipe and stores that had to be stowed away on the United States boats *Illinois* and *Kentucky*, the *Patrol* did not get under way until 4:45 p. m.

The secretary of the Commission, Capt. Carl F. Palfrey, accompanied the fleet as far as the head of the Des Moines Rapids Canal, where we left the United States survey boat *Illinois*. Chief Assistant Ockerson accompanied the *Patrol* all the way to St. Paul, which point we reached without damage or loss at 10 a. m. on May 2, having passed the 729 miles in one hundred and sixty-one and one-half hours, or at an average speed of 4.52 miles per hour, including stops that were made for coal, to distribute the tile bench marks (at Genoa, Wabasha, Red Wing, and Hastings), to detach and tie up the *Illinois*, four hours at Fountain City on account of rafts, one hour at Lake Side on account of wind, and seven and one-half hours at Hastings on account of the danger in passing rafts, logs, and numerous dikes in the night. About twenty-four hours in all was consumed in these stops, making the running speed 5.31 miles per hour.

The party was subsisted on the quarter boat *Kentucky*, well equipped for work, being furnished with tackle, tools, furniture, cooking outfit, table and kitchen utensils, bedding, towels, napkins, etc., no per diem being allowed, but all supplies and labor paid for by the Commission on properly signed vouchers.

The Kern precise levels Nos. 1, 3, and 5, with Kern precise-leveling rods Nos. 11, 13, 18, and 19, with the accompanying articles, were assigned to the party. They are the same kind of instruments and rods as are described in the report of the Commission for 1883, page 55.

On landing at Pig Eye, 2¼ miles below St. Paul, we immediately set to work to determine the necessary instrumental functions, in order for the field reduction of the work.

(1) These are the value of one division of the level tube and the distance at which it subtends 1 millimeter on the rod.

(2) The total and the relative value of the wire intervals in each instrument, thus finding the space intercepted at all distances by the wires on the rod, and their dif-

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ference, in order to be able to use their values subsequently to check the readings made and to find from the wire intervals obtained in all readings the length of the observation, tables being constructed at once.

(3) The amount of inequality of telescope rings to enable one to apply the proper correction to the excessive sights, it not being possible to eliminate this error by adjustment, and it not being a quantity that can be readily determined like that of inclination and collimation.

(4) The value of what has been called the "A" of rods, which is the distance from the first graduation of the rod to the bottom of the spur. Though in fact it is 100 millimeters less this quantity that is applied, all readings on the rods being 100 millimeters more than the distance above the first graduation. It is always necessary to apply this quantity when one observation (as backsight) is taken on a rod, and the other (as foresight) directly on the bench or on a rod graduated from the bottom, as when reading directly on a copper bolt leaded horizontally; also when reading the three wires directly against a gauge.

The first operation necessary is to make this distance the same for two rods that are to be used together. I devised a method for this that is extremely accurate. Owing to the two points to be measured between being in different planes, it is very difficult to measure this quantity directly. After they were made approximately equal the instrument was mounted on a stump and the rods alternately on another stump about of the same height and about 8 meters distant; the center wire was then set by elevating screw on to, say, the zero of graduation and the bubble read, and then the rod slightly filed off, which proved to be the longer, as determined by the readings of the bubble. When the bubble read the same, whichever rod was held on the spike the "A's" were of the same length. The absolute length of "A" can then be determined very closely by reading on the rod and on a stick set on the same point by measuring the difference between the length of the graduated portion intercepted and the length of stick intercepted.

The magnifying power of these Kern telescopes, determined by comparing the visual angle between the extreme wires as viewed through the telescope with the natural angle that the space intercepted between these wires subtend on a rod at the same distance, is 52.

Each instrument was provided with a large, square umbrella standing 5 feet high to protect it from the wind, also a smaller umbrella to protect it from the sun. The rod supports for turning points were footplates or pins. Stakes with nails in their top were used whenever the ground was too soft for other supports. The footplates give excellent results on ground in which there is sand or gravel if not very loose. The pins are better for ground loose on the surface or for woodland where there is a good deal of vegetable substance in the soil.

The general health of the party seemed to be affected during the first four weeks of the work. Diarrhea was the form of attack; this was probably caused by change of water. After this the health of the party throughout was good. Assistant Mann's ill health and inexperience with this particular kind of work made it necessary to make a change in assistants. He was therefore ordered back to office on May 27. A. L. Johnson, appointed by the office as assistant, reached the field and began work on May 30. All of the party excepting the chief were inexperienced in precise level work.

On the morning of the 6th of May actual field work was begun by one party; O. W. Ferguson, observer. Afternoon of the same day Assistant Mann took same party and began work, Assistant Ferguson working with the other party.

Line of work.—It being conducive to good work to operate on hard and well-settled ground, and it also being conducive to small probable error to shorten the line, the line of work followed the line of the railroads whenever they were accessible to the river, care always being taken to set the foot plate or pin so that they would not be disturbed should a train pass by. The rear support was never disturbed until the forward one had been fixed, thus we were always prepared to be surprised by an express or freight train; the greatest damage they could do, which was often done, was to drive the instrument from the track just before being able to complete the forward observation. Work, however, can be carried along more rapidly on railroad line than in most any other place, there being no brush to cut, no soft ground to contend with, and the grades are not sufficiently abrupt to interfere with the length of observation. This line of work continues from St. Paul along the line of the Chicago, Burlington and Northern Railroad to a point 3¼ miles below Diamond Bluff, where it leaves this road and follows through the country, through Trenton, Wis., crosses the slough of Island 24, down Island 24 to opposite Red Wing, where we made a river crossing by reciprocal leveling, then down along the right bank to Wacouta, where we reach Lake Pepin; continues along down the right bank of Lake Pepin to 2 miles below Lake City, a distance of 29 miles without any railroad; then, via Chicago, Milwaukee and Saint Paul Railroad, along the right bank to Wabasha, Minn.; then along the right bank without railroad or other road 8 miles, to Alma, just above

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which town we made another river crossing over into Wisconsin; then the line followed the Chicago, Burlington and Northern Railroad to Winona, where we made another crossing on the Chicago and Northwestern Railroad Bridge; then we follow the Chicago, Milwaukee and Saint Paul Railroad and cross on their bridge above La Crosse to Wisconsin, following the Chicago, Burlington and Northern Railroad to Prairie du Chien, where we cross back to the Iowa side via the trestle bridge of the Chicago, Milwaukee and Saint Paul Railroad, following this road to 4 miles below Bellevue; thence along the right bank of river to opposite Island 253, crossing over by reciprocal leveling and following the left bank a distance of 10 miles without railroad to Arnold Landing, where we reached the line of the Chicago, Burlington and Northern Railroad again and follow it to Savanna, where our work connected with the precise-level bench marks established by the Commission in 1883. Thus it will be seen that 84.4 per cent of the main line followed the railroads and 15.6 per cent followed along the river shore. It is to be noticed that this line of precise bench marks is very accessible to the river, yet they are all where they should remain for many years. Proper sacrifice was always made to keep in reach of the river.

Moving quarter boat.—The *Kentucky* was not supplied with steam power. Her timbering was very weak, though the planking was quite good. The boat was dropped by hand from point to point as the work progressed. This was done as far as possible when it was calm. At such times the work of moving the boat was easy, but it was not possible always to wait for calm weather. Also when it appeared to be calm in one place it would be quite the contrary a mile or two distant. No little anxiety was felt in passing the many dikes and along the riprapped shores toward which the boat would often manifest a strong attraction, what with the wind and current trending to the bank, sometimes it scraped the rocks. At the head of Island 46, coming suddenly under the protection of the timber, the wind having before kept the *Kentucky* off the shore, she all at once started for land, and crushed a skiff before she stopped against the bank, which was of earth. From the start throughout the season improvement was made in handling the boat. The best results could be obtained by the crews of six oars each in the front, a sweep on each side in front, and a steering sweep behind. In this manner we moved the boat when the wind was quite adverse; often all this power would be required to keep the boat off the shore while she drifted with the current. The most dangerous navigation was through Lake Pepin. The bluffs are very high, and the wind uncertain, blowing only in spots and in different directions. Out in the lake it may blow offshore, while under the bluffs there will be an underwhirl that blows toward shore. This last drove us to the rocks a couple of times in spite of all we could do, but with the aid of pike poles she touched quite gently; then by hitching a line pretty well back she was towed to harbor. At Kings Coulee such a violent storm came up that the spars gave way and the *Kentucky* was blown hard against the gravel, but one party reached the boat at this time, and she was kept from pounding on the bottom by props and pikes until the storm abated and the spars were reset.

Connections with old work.—The set of charts furnished me were plentifully marked with locations and short descriptions and elevations of old bench marks. These were all searched for whenever our line passed in the same vicinity, and if found, according to instructions, side lines were run to them if they could not be taken in the main line. Comparatively but few of them could be found and a large proportion of those found were in bad condition, the nails and tacks of which they were composed in several instances being rotted loose. Some quite permanent old bench marks were found in the towns along the route. The elevations of these old bench marks as given on the maps were a source of some annoyance. We never could check with them nor come within from a foot to 40 feet of any constant difference from these elevations. Through the courtesy of the Rock Island office more recent descriptions and continuous elevations and of some more recent bench marks were furnished me from time to time. In some cases this information was a little behind the progress of the work, but otherwise all of these (of which I submit the list) that were near the line of work and could be found were connected with.

All of these gauges found were also tied onto and the datum of cities passed through were connected with when there had been any datum established. In these connections with the old benches there was a general tendency to quite good agreement for ordinary levels, with some exceptions.

The elevations furnished in "gauges and bench marks" were found to vary 1.2 feet in the widest places when the elevations were subsequently determined in reference to Cairo datum. Elevations were also quite generally taken of the "base of rail" in front of depots passed on the line of work.

No old bench mark connected with was given a new number; it was designated by its old number, as B. M. "a," or, if it had no number, as old B. M. so and so.

New bench marks.—These were of two denominations, permanent and temporary. The permanent ones were located with great care, with a view to remaining an indefinite period. They were most all set where they could be easily and accurately

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described, as at intersections of roads. corners of fences, close in the corners of door yards, many of them not far from railroad bridges, close to the limit of the right of way, and generally on the railroad side of the fence. This kind of permanent bench mark was designed by Chief Assistant J. A. Ockerson. It is described and illustrated on page 3485 of the report of the Commission for 1891. It consists of a vitrified tile, manufactured by the Laclede Fire-Brick Company, of St. Louis, 18 by 18 inches on the bottom, 4 inches thick, and 17¼ by 17¼ inches on the top. The letters Mississippi River Commission are marked in the tile before baking; also around the center there is cast a circle, which is the characteristic mark of the bench mark, the same kind of a tile, but marked with a square and triangle, respectively, being used for survey monuments and triangulation stations.

In the center of this circle and in the center of the tile a hole is cut 1¼ inches deep and three-fourths of an inch in diameter. Into this hole is leaded a copper bolt three-fourths of an inch in diameter and standing with rounding top one-third of an inch above the surface of the tile. The top of this bolt constitutes the permanent bench mark. The top of the tile is set about 3 feet below the surface of the ground, the bottom of the hole being first tamped hard and made horizontal by trying it with a common hand level about a foot long before the tile is put in place. It is then well settled and the edges tamped up before it is connected with as a permanent bench mark. Over this copper bolt and concentric with it is set an iron pipe 4 inches in diameter resting in a flat circular recess cast in the tile to receive it. The bottom of this wrought-iron pipe is spread about three-fourths of an inch, making it rest better on the pipe and more difficult to pull off of its seat after the earth is tamped around it.. This pipe is 3 feet 11½ inches long and surmounted by a heavy cast-iron cap fastened firmly to the pipe by two opposite brass screws having small square heads. On this cap is cast the letters "Mississippi River Commission, U. S. P. B. M., 1891." The elevation of the slightly elevated ring in the center of the top of the cap constitutes another bench mark, its elevation being determined in duplicate, the same as any other bench mark, and not deduced from the length of the pipe. There were 106 of these tile bench marks furnished for the line. As the United States steamer *Patrol* passed up the river these were left in the town along the line in batches of from eleven to twenty, so that the quarter boat need not be so much loaded and incumbered. They were set in places that distributed them well over the distance covered. Very few of these are set in towns, as in such places the stone piers, culverts, and rock foundations of substantial buildings furnish excellent places to set copper-bolt bench marks in these rocks. Their location can be perfectly described, and as they take up so little room and are entirely out of the way, they are rarely disturbed. This kind of permanent bench marks are made of copper bolts 3 inches long and three-eighths of an inch in diameter. One end is filed flat or slightly rounding; the other is upset or flattened out. A hole is then cut by a stone drill three-fourths of an inch in diameter to such a depth that if the bolt is to be set vertically it will just reach the surface of the stone, or if it is to be set horizontally it extends about one-fourth of an inch in beyond the surface, as it is thus better protected. Melted lead is then poured around the copper bolt in position and tamped in compactly by punches. The letters

U. S.
⊙
P. B. M.

are then cut around the copper bolt of such size and depth that they will last many years.

This kind of a bench mark set horizontally, the center being marked with a prick punch, is very satisfactory; as it is never built over, it will not be worn down and can not easily be covered with rubbish.

The bench marks characterized as temporary (T. B. Ms.) were made of stakes carefully driven and nails driven in their tops. These were only used when nothing better could be found. Usually they were either spikes driven in stumps or in the bases of trees, or the highest points in squares worked in the rock of culverts, bridge piers, bowlders, or in the natural ledges of rocks, and marked "U. ⊡ S." The location of all marks were well described in the note books.

There were set on this line of tile	Permanent Bench Marks	106
There were set on this line of iron cap	Permanent Bench Marks	106
There were set on this line of copper bolt	Permanent Bench Marks	57
Two at Hastings cut in rock	Permanent Bench Marks	2
Total number of permanent bench marks		271

The number of temporary bench marks of sufficient permanency to be given in the final list of descriptions	214
Number of old United States bench marks connected with	49
Number of city bench marks connected with	7
Number of gauges bench marks connected with	12
All of these points in number	553

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are described in the list of descriptions and their elevations given above Cairo datum plane in both meters and feet.

In the main line of work there were 396 stretches, aggregating 484.68 kilometers; consequently the average length of a stret h was 1,224 meters.

There were 297 side line stretches, aggregating 32,311 meters, giving 109 meters as the average length of a side line.

Methods of work.—The principle followed was so far as possible to divide and fix responsibility so that no member of the party would feel unimportant but that any failure would to a degree attach to him, also to educate the individuals of the party up to appreciate the degree of precision sought. Men differ very much in their ideas of exactness. To a very ignorant man, as I have had occasion to observe in previous years, a distance within 6 inches is considered as exactness.

In the precise level work an unmeasurable quantity if it can be demonstrated to exist in the shape of an error, especially if of a constant or accumulating character must be obviated or eliminated.

The observer was responsible for the safe handling and moving of his instrument while at work, he being the only person that handled it.

The recorder was responsible for the safe keeping of the note book and for writing in all necessary data.

The rodmen for the safe handling of t e rods at all times and places. This is a task, for they take up a good deal of room, are often crowded in the skiffs, likely to be scratched and bruised in carrying through wire fences, woods, and among other objects, and if scratched but little each day would be greatly defaced at the end of the season. So on down to the axmen and cook, who contribute largely to the success or failure of the work.

At the beginning of work the errors of collimation and inclination are reduced to small quantities by repeated observations and reversals; this operation generally requires from ten to fifteen minutes. Then the instrument being set up at the proper distance, according to the weather, of from 40 to 100 meters, the rod on the bench mark is read, the recorder quickly takes out the intervals and notices if they bear the proper ratio to each other, writes down the size of bubble, number of rod read, and makes out the mean of the three wire readings and writes it in the proper column. Probably before all of this is finished the observer begins to read the fore rod. The fore sight is thus read very soon after reading the back sight, so the errors due to time are relatively small. The instruments and rods are continuously changing their heights for some time at least after being set, and within these limits the longer the time the greater the change; also parts of the instrument become differently expanded, and the refraction due to a different air floating across the fore sight becomes different. In these particulars, time errors, I believe we greatly excel doing precise leveling work, by generally eliminating errors instead of attempting to measure them.

The best general elimination of refraction, which is the source of much error, is to take the fore sight of the same length as the back sight and through the same air. The bubble was always read in the center, a custom that was introduced by U. S. Assistant Engineer, J. B. Johnson, on the line from Carrollton to Biloxi. It is by far the best method, most precise, and reduces the necessary office work.

The recorder keeps the sum of back sights and fore sights running equal by sending the fore rodman long or short the needed amount.

At the close of the work the errors of collimation and inclination are measured by reverse observations and applied together with the error due to inequality of telescope rings all summed in millimeter per meter and applied to the amount of the excess of fore sights over back sights, or *vice versa*, with the proper sign. All stretches were duplicated in opposite directions by the same level party. Until we reached Lacrosse, 140 miles from the starting point, the back sights were uniformly read first; then the fore sight was read. On receiving the recommendation from the president of the Commission, forwarded to me by Chief Assistant J. A. Ockerson, that the back sights and fore sights be taken alternately first, this system was then adopted. It eliminates quite completely the error due to change of *height of instrument* during observations, but it does not eliminate any change that may persistently take place in the change of heights of rod supports between fore sights and back sights on the same rod; neither does any other system, but this system tends to magnify this error, as at every alternate station the time elapsing is longer. I have known since 1881, when for some time during freezing weather I practiced this method, that better results could be obtained in this way than by always taking the back sight first. This method during this season showed some improvements in our checking, but nothing very marked, as there appeared to be very little constant error in the work previously.

After the recorder had made out all of the mean wire readings and summed these and the total intervals for each page and written in their proper places the descriptions of all bench marks connected with, he handed the notes to the rodman to be

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checked. The rodman then went over the work of the recorder, checking all deductions and signing his initials at the foot of each page, showing that the page had been checked and by whom. After making all necessary corrections the recorder called off the interval of each sight and the rodman called back to him the distance given in meters by the table for each interval; these were then summed for both back sight and fore sights. Then the recorder made out by summation and substraction the difference of elevation with its proper sign. If the run under consideration were a "direct" run, the back sights were called (+) plus and the fore sights were called (—) minus. The difference was then taken between these sums of plus and minus readings and the forward bench (or unknown point) referred to the rear bench (the known point) from which it had been determined, with the proper sign prefixed. It was also written after that the forward bench was above or below the rear bench as there was an excess of plus or minus readings. The same object was reached in the "reverse" line by always considering the backsights (—) minus and the foresights (+) plus.

The length of each stretch was made out at the same time, and from the table constructed for the purpose it was seen whether the precision of the work of the stretch found by comparing one line with the other was within the limit of error allowed, which was $3^{mm}.\sqrt{\text{Length of the loop in kilometer units}}$. If it came within this it was passed unless something was discovered that discredited one of the lines. If not, it was rerun until this limit was satisfied. The limit of error allowed by the Commission on all previous precise leveling has been $5^{mm}.\sqrt{\text{Distance in kilometer units between benches}}$. By this old limit the allowable error between two benches 1,200 meters apart would be $5{,}475^{mm}$, while the new limit for the same distance would be 4,647. It is seen that the new limit is appreciably more narrow than the old. This having been done, the recorder handed the notes to the assistant engineer or observer who looks the work through to see that the benches are rightly numbered and referred to, that the differences of elevation are reasonable, correct in sign, and apparently correct in amount. All of these results of field work and reduction are entered on a field tabulation by the observers. This tabulation is made on foolscap paper and consists of nineteen columns.

Column 1 gives the name and number of the B. M. under consideration and to which the work has ben carried.

Column 2 gives the bench from which it was determined.

Column 3 gives the length of the stretch in meters.

Column 4 gives the total distance in meters from the initial point.

Column 5 gives the observer, and whether main or side line.

Column 6 gives the direction of line.

Column 7 gives the differences of elevation with sign and also the mean difference of elevation.

Column 8 gives the residuals of each line from the mean.

Column 9 gives the summation of the residuals in the direct line.

Column 10 gives the same quantities for the reverse line.

Column 11 gives the probable error of the mean difference of elevation as determined for each stretch.

Column 12 gives the probable error of the resulting elevation of this bench as computed from the start.

Column 13 gives the elevations as carried in meters.

Column 14 gives the elevations as carried in feet.

Column 15 gives the elevations in feet as per the old list.

Column 16 gives the corrections to be applied to old elevations to bring them to the precise level results.

Columns 17 and 18 give the summation of the residuals of each observer from the start.

Column 19 gives the remarks.

From this tabulation, using the lengths of stretches and residuals from the mean of each stretch, the two independent lines direct and reverse are plotted. This profile gave the tendency of the errors, also the total deviation of the two lines. On this profile was put various other information, as name of locality, dates, etc. There was no marked tendency of the lines to show a constant error. The divergence of the two lines and more could be readily accounted for by uncompensated accidental errors of observation. The lines crossed several times. The greatest deviation from the mean in the field plot was 4 miles below Lynxville, where it had reached $+16.4^{mm}$. and $-16.4^{mm}. = 32.8^{mm}$. The same plot showed this divergence to be $+7.1^{mm}. -7.1^{mm}$. at the end of the work at Savanna. The plot of the office reduction shows the lines crossing about the same number of times, but the origin of the residuals in three stretches were reversed in the field work bringing the lines nearer together in places above but showing the maximum deviation from the mean to be at the close of the work at Savanna $+16.5^{mm}$. and -16.5^{mm}. being about the

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same + 15.9 ^{mm}. and — 15.9 ^{mm}. at Dubuque, Iowa. At no place does the divergence of these lines reach one-half of the limit [allowed for each stretch] 3^{mm}. √Distance of loop in kilometers after the start, and it is away inside here.

All bench marks established and old points connected with and landings of the quarter boat were marked in their proper location on the set of charts furnished.

River crossings.—In making river crossings the system of reciprocal leveling was used. Two observers, one on each side of the river, making simultaneous readings, give the best elimination of refraction and a perfect elimination of curvature, and when combined as given below all instrumental errors are eliminated.

The instruments are set up on opposite banks; 10 meters below one instrument and above the other good stakes are well driven and nails in tops for rod supports. Each observer then takes a reading on the rod 10 meters distant with telescope normal and "level direct." With the rear instrument this reading is a back sight; with the forward instrument it is a fore sight. Each observer then reads the long sight across the river. With the rear instrument this is a fore sight, and with the forward instrument a back sight.

The first reading is taken with telescope normal level direct.

The second reading is taken with telescope normal level reversed.

The third reading is taken with telescope inverted level reversed.

The fourth reading is taken with telescope inverted level direct.

If the distance is too long for direct reading on the rod, which will be the case when the distance is over 240 meters, targets are moved in place by signals, the center wire only being read and recorded by the recorders at the rod. Each observer then reads the short distance with telescope inverted, level reversed. Then the parties change sides and read in the same manner. The mean of all sixteen of these results, without applying any corrections, is one determination, in which all errors, including inequality of telescope rings, are eliminated. The same can be repeated and called the reverse line or these results may be combined in different ways for inspection to satisfy the observers of their correctness or need of further observations. This mean of sixteen observations will rarely fall outside of the allowable limit of error if the conditions are reasonably favorable.

Obstacles to good observing.—In the work of precise leveling the elements that are against precision and that must be contended with are: First. Ground that is yielding. Second. Wind, which shakes both the instruments and rods, changing their elevation during observations or between observations, rendering observing slow and uncertain. Third. A want of uniform temperature, density, and humidity in the air, causing changes in refraction sometimes of disastrous magnitude. Fourth. Vibrations in the air, caused by radiation of heat either from the ground to the air or from the air to the ground, causing the wires to appear to dance about on the rods. Fifth. Shining of the sun, causing unequal expansion of the instruments used.

(1) The unsteady ground must be avoided or the necessary precautions taken in setting the instruments and rods and provisions for moving around them made, such as temporary platforms supported away from the instrument.

(2) During windy weather the rod supports must be firm; then, unless the wind is too strong for the rodmen to hold their rods well, the large umbrellas furnish sufficient protection to enable one to continue work. Otherwise, when the limit is about reached work should be discontinued.

(3) Irregular refraction can often be detected by a change of the position of the wires on the rod, also by noticing the feeling of the different clouds of air moving on the line; the defense is to take short observations and quickly, or discontinue work.

(4) There are but two measures that can be taken against the bad effect introduced by tremulous air: first, by setting the instrument and rods in such positions that the line of sight will not lie close to the disturbing surface; second, by shortening shots. When they become too short for profitable work, before this dancing motion can be narrowed down, which is about 35 meters, work should be discontinued.

(5) The sun umbrella, though not offering complete protection, affords enough protection to enable work to be continued.

Best conditions for work.—The best conditions for work are when none of these causes of disturbance obtain. On solid ground, of uniform configuration, with the wind gently blowing about a mile or a mile and a half an hour, sufficient light to read well, but otherwise entirely cloudy.

Measure of precision.—This is found in the answer to the question "How close does one line agree with the other line between the same points run by the same party in opposite direction?" The system followed in the work and manner of reading three wires for each observation, checking on the intervals, even if the line is run over but once, is a most infallible determination of the difference of elevation between the two points within narrow limits. This fact can be demonstrated from the results of any field season. One learns what they may expect from what experience has shown will happen, also from the theory of probabilities, of the liability of the happen-

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ing of a hypothetical adverse combination. During this season's work, of the 768 loops or 1,536 lines, only 9 have shown a discrepancy as large as ten millimeters and only one pair of lines varied as much as 21.5^{mm} from each other. These were mostly the result of inexperienced observers.

If there are "constant" errors in the work, their sum appears in the residuals, though the mean of the two lines, run in opposite direction, eliminate them. It can be safely assumed that there are always some errors of the nature of a "constant," if in some regions it is very small. Therefore, the probable error for each stretch as computed is really too large by the amount of this constant accumulation, and the probable error of final result at the successive benches, as computed from the initial point, is too large for the same reason. However, the probable error of the final result at Savanna, in the 484.68 kilometers in the field reduction was $\pm 13.5^{mm}$. In the office reduction it became ± 13.8, giving the probable error per kilometer of the final reduction $\pm 0.625^{mm}$.

The precise levels of the Mississippi River Commission have been followed by ordinary Y levels and water surfaces by their topographic and hydrographic parties for a distance of about 1,000 miles, and no error has been discovered to have been made in the precise level work. This shows conclusively the absence of large errors. This fact further demonstrates the correctness of the conclusion that the criterion of precision is a reliable one.

Results of work.

	Kilometers.	Miles.
Length of line completed=main line=	484.68=	301.23
side lines=	32.31=	20.07
Total line of completed work=	516.99=	321.30

Number of times that line was run.	Length of line in meters.	Total length of single line run.	Thousandths of the whole line run.
1..........	515	515	1
2..........	448,283	896,566	868
3..........	10,973	32,919	21
4..........	43,884	175,536	85
5..........	4,802	24,010	9
6..........	3,738	22,428	7
8..........	4,796	38,368	9
Total	516,991 =321.3 miles.	1,190,342 =739.8 miles.	1,000

Proportional part of whole line run more than twice=13 per cent. Number of single runs rejected in all=11. These were rejected because their value, as compared to the mean value of other lines over the same stretch was unreasonable, considering the precision of the work.

Total number of days in the field 167
Average length of line completed per day ....miles.. 1.924
Excluding the 24 Sundays during which there was no work done, the average progress per day becomes ....miles.. 2.25

The casualties happening to the party or property were very few. The quarter-boat reached Savanna safely; the instruments suffered from no serious accident, the most severe being the breaking of a collimating screw.

Very good behavior was quite uniformly shown by the crew, though three men were discharged at one time for insubordination, intoxication, and for leaving the boat without privilege. I noticed that gaming cards have a bad effect on a crew. They produce laziness and are quite certain to lead to gambling for money. No game of cards was subsequently allowed on the boat. The men always proved themselves faithful and efficient. Assistant A. L. Johnson developed great skill as an observer. The success of the work is also due to the care of recorders F. B. Williams, I. M. Durfee (who, however, left the party after the first three weeks on account of sickness), and John P. Baker.

Respectfully submitted.

O. W. FERGUSON,
U. S. Assistant Engineer.

Capt. CARL F. PALFREY,
Corps of Engineers, U. S. A.,
Secretary of the Mississippi River Commission.

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REPORT OF MR. O. W. FERGUSON, ASSISTANT ENGINEER, ON OFFICE REDUCTION OF PRECISE LEVELS, ST. PAUL TO SAVANNA, 1891.

MISSISSIPPI RIVER COMMISSION,
OFFICE OF THE SECRETARY,
St. Louis, Mo., March 14, 1892.

CAPTAIN: I have the honor to present my report on office reduction of precise level work between St. Paul, Minn., and Savanna, Ill.

Office work was begun on October 22, 1891, by myself and Recorders F. B. Williams and John P. Baker.

The notes of this work are contained in 49 precise level note books Nos. 1915 to 1963, both inclusive. An index of these books was first made, showing what each contained. This and other information was properly printed on the covers of the books.

Observations for the close of the season of all instrumental factors were then made for Kern levels Nos. 1, 3, and 4, and for level tubes Nos. 3, 5, and 6. There was then made a recomputation for these factors of the observations taken at the beginning of the field season and the later observations also computed and checked. The proper tables and values were then made out for all observations. The values as found from the May observations were used to the middle of the season; those made in October for the remainder of the season.

These functions were:

	Date of observation.	
(1) Value in angle of one division of level tube No. 5, and the distance at which one division subtends 1^{mm} on the rod........	May	41, 891
Value of the same for the same....................................	October	28, 1891
Value of same for same for tube No. 6	May	4, 1891
Value of same for same for tube No. 6	October	27, 1891
Value of same for same for tube No. 3	May	2, 1891
Value of same for same for tube No. 3	October	27, 1891
(2) Observations to find the value of each interval and the total interval for all distances for the Kern level telescope No. 1, and construct a table giving the distance for a given interval......	May	4, 1891
The same for the same	September	25, 1891
The same for the same	October	27, 1891
The same for the same, Kern telescope No. 3.......................	May	4, 1891
The same for the same, Kern telescope No. 3.......................	October	28, 1891
The same for the same, Kern telescope No. 4.......................	May	4, 1891
The same for the same, Kern telescope No. 4.......................	October	27, 1891
(3) Observations to find the amount of inequality in millimeters per meter, with sign to Kern level telescope No. 1, for observations..	May	2, 1891
The same for the same	October	27, 1891
The same for the same, telescope No. 3............................	May	4, 1891
The same for the same, telescope No. 3............................	October	28, 1891
The same for the same, telescope No. 4............................	May	4, 1891
The same for the same, telescope No. 4............................	October	27, 1891

Comparisons were then made of the rods XI, XIII, XVIII, and XIX, with the aid of hair-spring dividers and magnifying glasses; with the three meters laid off on the 15-foot iron bar of the U. S. Lake Survey, it being standard at a temperature of 69 °.7 F.

Eight measurements were made for each rod, observations being taken of temperature and the measured lengths reduced to standard. The coëfficient of expansion used being 0.00000632, deduced from the legend on the rod. These rods all proved to be a little longer than standard.

A résumé of all of their values was then made in tabulated form.

Tables giving the values of instrumental constants.

INEQUALITY OF TELESCOPE RINGS.

No. of telescope.	Date of observation.	Dates to be used between.	Value of P′ in seconds.	Correction in millimeters per meter.
1	May 2. 1891	May 2 to July 20, 1891	+0.028	+0.000
1	Oct. 27, 1891	July 21 to October 19, 1891	−2.490	−0.012
3	May 4, 1891	May 2 to July 20, 1891	−1.643	−0.009
3	Oct. 28, 1891	July 21 to Oct. 19, 1891	+0.768	+0.004
4	May 4, 1891	May 2 to Aug. 10, 1891	−7.077	−0.034
4	Oct. 27, 1891	Aug. 11 to Oct. 19, 1891	−3.254	−0.016

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Tables giving the values of instrumental constants—Continued.

ANGULAR VALUE OF WIRE INTERVALS.

No. of telescope.	Date of observation.	Dates to be used between.	First interval.	Second interval.	Total interval.
			h. m.	*h. m.*	*h. m.*
1	May 4, 1891	May 2 to July 6, 1891	13 59.04	13 56.04	27 55.06
1	Sept. 25, 1891	Sept. 22 to Oct. 19, 1891	7 44.81	7 58.68	15 43.53
1	Oct. 27, 1891	......do	7 46.81	7 56.13	15 42.93
3	May 4, 1891	May 2 to Oct. 19, 1891	8 29.10	8 54.52	17 23.58
3	Oct. 28, 1891	......do	8 29.62	8 55.54	17 25.18
4	May 4, 1891	May 2 to Sept. 22, 1891	8 02.21	9 08.51	17 10.71
4	Oct. 27, 1891	Sept. 22 to Oct. 19, 1891	7 56.32	8 3.00	15 59.35

Length of iron rod used to connect through iron pipe with tile P. B. Ms. =1,221.0mm.

ANGLE IN ONE DIVISION OF LEVEL TUBE.

No. of tube.	Date of observations.	Dates to be used between.	Seconds in 1 division.	Subtends 1 millimeter at meters.
3	May 4, 1891	May 2 to July 20, 1891	1.866	114.3
3	Oct. 27, 1891	July 21 to Oct. 19, 1891	2.544	81.1
5	May 4, 1891	May 2 to July 20, 1891	1.643	125.5
5	Oct. 28, 1891	July 21 to Oct. 19, 1891	2.233	92.4
6	May 4, 1891	May 2 to July 20, 1891	1.622	127.2
6	Oct. 27, 1891	July 21 to Oct. 19, 1891	1.036	199.1

LENGTH OF "A," RODS XI, XIII, XVIII, AND XIX.

No. of rod.	Date of measurement.	To be used between dates.	Distance from first gradient to foot of spur.	"A" of rod.
			Millimeters.	*Millimeters.*
XI	May 14, 1891	During whole season	45.10	54.90
XIII	....do	......do	45.10	54.90
XVIII	May 13, 1891	......do	44.45	55.55
XIX	....do	......do	44.45	55.55

ROD CORRECTION.

No. of rod.	Date of measurement.	To be used between dates.	Length of 3 meters on rod.
			Millimeters.
XI	Oct. 31, 1891	During the season	3000.357
XIII	....do	......do	3000.406
XVIII	....do	......do	3000.263
XIX	....do	......do	3000.403

Mean length of the 4 rods used = 3000.357.
Mean length of the meter used, 1000.119.
Therefore the difference in elevation between any 2 bench marks will be numerically greater than that given by 0.119 millimeter per meter.

A relatively large change is noticed in the values of inequalities of telescope rings as found in May and October. This was to be expected, as the wear during the season is considerable.

A new set of wires were put in instrument No. 1, and observations taken to find their value on September 25. The old wires had slacked down and become useless. The intervals of this new set of wires were found very little changed on October 27. Also the intervals in instrument No. 3 remained quite unchanged.

One wire was broken out of instrument No. 4 at Dubuque, and it was not repaired in time to be used but one day in the field thereafter.

Level tubes Nos. 3 and 5 increased their curvature during the season; that of tube No. 6 diminished. Their variation must have been due to the way they bound in the level case.

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No individual corrections were made for rods from bench to bench, as all rods were about equally concerned in the results, and the final correction would be very small.

The mean value of a meter of the three rods used 1000.119^{mm}. Therefore the difference in elevation between any two bench marks will be numerically greater than that given by the quantity 0.119^{mm} multiplied by the difference in elevation in meters.

This correction was applied to every bench. A table was then made out giving the limit of discrepancy in millimeters allowed in closing a loop of a given length up to 7400^m from the formula:

$$\text{Allowable discrepancy} = 3^{mm} \sqrt{\text{Distance in kil. units in loop.}}$$

Also a convenient table for converting meters to feet. All quantities in the note books affecting the reductions were then checked, and each item marked by a check mark in red ink, and the name of the person checking signed in red at the end of the book.

The intervals, distances, mean wire, and summations of each page were checked; also all three wire readings were summed at the bottom of each page, divided by three, and seen to give the same quantity as the sum of the means.

All river crossings and connections with gauges and horizontal bolts where the bubble is read away from the center were recomputed. These quantities for each stretch and each run were transcribed on computation paper and the length, direction, and difference of elevation, after being corrected for errors of collimation, inclination, and telescope rings, with its sign were computed and written out. Thus an entirely new computation was made. It was then compared with the field reduction in all of these particulars. If any differences appeared they were looked up, even to the tenth of a millimeter, to see how they had arisen.

Beginning then at St. Paul these results were tabulated anew on the proper sheets.

Column 1 gives the length of each stretch in kilometers. The * indicates that the B. M. is not in the main line.

Column 2 gives the bench under consideration to which the line has been carried.

Column 3 gives the B. M. from which this B. M. has been determined.

Column 4 gives the continuous sum of distances in the main line from the initial point.

Column 5 gives the direction that each line was run.

Column 6 gives the difference in elevation between these two bench marks, with sign of each run and the mean of all.

Column 7 gives the residuals of each line from this mean difference of elevation.

Column 8 gives the probable error of each stretch $= 0.6745 \sqrt{\frac{\Sigma v v}{m (m-1)}}$

Column 9 gives the probable error of each elevation of this point computed through all of the intermediate benches.

Column 10 gives the elevation above the Cairo datum in meters.

Column 11 gives the elevation above Cairo datum plane in feet.

Column 12 gives the rod correction to be applied at each bench.

Column 13 gives the initial of the observer (F.=Ferguson, J.=Johnson, M.=Mann, W.=Williams).

All of these quantities have been rigidly checked. From the lengths of the stretches in the main lines and the residuals of each line successively summed from the initial point a profile of the office reduction is made. In cases where more than one direct or reverse line was run the mean of the residuals is taken. This profile gives the sign of the errors and the names of all places passed through, also the numbers or names of bench marks. The full line is the direct line; the dotted line is the reverse line, both of which are independent from the start, excepting that the points used are common at every bench mark in the main line. The distance between these lines at any bench gives the sum of the divergence of the lines at that bench from the start.

To show on the profile how the old line of elevations compares with the precise level elevations, the old line is plotted by their variations from the precise elevations. They are shown by the full red line. When the red line is below the mean precise level line it shows that the old elevations were too low by that amount.

(1) The difference in sea level at St. Paul on old B. M. "A" is 5.850 feet, the Rock Island office sea level being higher.

(2) The difference therefore between Rock Island datum as given at St. Paul on old B. M. "A" and Cairo datum as per precise levels, 27.11 feet. Rock Island datum being higher.

(3) The difference in sea level at Savanna on old B. M. 34 is 6.315 feet, the Rock Island office sea level being higher.

(4) The difference therefore between Rock Island sea level as given at Savanna on old B. M. 34 and Cairo datum plane, as per precise levels, is 27.575 feet, Rock Island datum being higher.

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Connection at Savanna was made by running in duplicate from old United States permanent bench marks 62, 63 and 60 to our T. B. M. 353. Thus three independent elevations of T. B. M. 353 were found after applying all corrections. They were quite concordant.

The mean of these three different elevations of T. B. M. 353 was taken for its true elevation=607.450 feet above Cairo datum plane. The elevation of this T. B. M., as carried down from Savannah by precise levels after applying rod correction = 176.88604^{m}=580.340 feet. Constant to be added after all corrections are made = 8.26314^{m}=27.11 feet.

The number of points, of which the elevation is computed is 696. The number of points described in the list of bench marks is 553.

All elevations are first determined in meters and then converted into feet.

No large error was found in the field reduction. One error of 10^{mm}, one of 6^{mm}, and one of 3^{mm}, several of over 1^{mm}, and quite a number with magnitude less than 1^{mm}. The probable error of the final result is computed for each bench by obtaining the square root of the sum of the squares of the probable errors of each stretch intervening between it and the initial point. This, for the last bench in the line, gives the probable error to be 13.77^{mm}.

To find the probable error per kilometer, we assume the whole line of 484.68 kilometers to be divided into stretches of 1 kilometer in length. Then the probable error per kilometer will be such that 484.68 times its square will give the square of 13.77^{mm}, ... $484.68x^2=(13.77)^2$ .... $22.015x=13.77$. Probable error per kilometer $=x=0.625^{mm}$.

The value found for x for the first 50 kilometers was	$\pm$ 0.66
The value found for x for the first 100 kilometers was	$\pm$ 0.65
The value found for x for the second 100 kilometers was	$\pm$ 0.66
The value found for x for the third 100 kilometers was	$\pm$ 0.61
The value found for x for the fourth 100 kilometers was	$\pm$ 0.58
The value found for x for the last 85 kilometers was	$\mp$ 0.60

Running very regularly and showing that all the work is of about the same grade of precision.

Recorders F. B. Williams and John P. Baker have assisted me in this final computation, and are to be commended for their rapidity, accuracy, and comprehension of the work.

The work of checking the conversion of meters to feet on Mr. Paige's tabulation from Duluth to St. Paul, and appending the elevations in meters and feet to his description, has also been done.

Respectfully submitted.

O. W. FERGUSON,
U. S. Assistant Engineer.

Capt. CARL F. PALFREY,
Secretary Mississippi River Commission.

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891.

BY Assistant Engineers O. W. Ferguson and A. L. Johnson.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			Km.		Meters.	Mm.	Mm.	Mm.	Meters.	Feet.	Mm.	
	P. B. M. 66								225.0646	738.408	+0.44	F.
0.014	T. B. M. 1	66 P. B. M.	0.01	Dir	− 0.5397	−0.05	0.0		224.5248	736.637	+0.38	F.
				Rev	− 0.5398	+0.05						F.
				Mean	− 0.53975							
0.014	P. B. M. 65	1 T. B. M.	0.03	Dir	− 0.6799	+0.10	0.1	0.1	223.8449	734.406	+0.26	F.
				Rev	− 0.6797	−0.10						F.
				Mean	− 0.67980							
0.595	P. B. M. 67	65 P. B. M.	0.62	Dir	− 1.7821	−0.15	0.1	0.1	222.0624	728.558	+0.05	F.
				Rev	− 1.7824	+0.15						F.
				Mean	− 1.78225							
0.430	P. B. M. 68	67 P. B. M.	1.05	Dir	− 1.6398	−0.95	0.6	0.6	220.4215	723.174	−0.14	F.
				Rev	− 1.6417	+0.95						F.
				Mean	− 1.64075							
*0.012	Old B. M. *a*	68 P. B. M.		Dir	+ 1.2162	+0.15	0.1	0.6	221.6380	727.165	0.00	F.
				Rev	+ 1.2165	−0.15						F.
				Mean	+ 1.21635							
*0.011	Old B. M. 2½	68 P. B. M.		Dir	− 2.44150				217.9797	715.163	−0.44	F.
0.060	P. B. M. 70	68 P. B. M.	1.11	Dir	+ 0.4515	0.00	0.0	0.6	220.8730	724.655	−0.10	F.
				Rev	+ 0.4515	0.00						F.
				Mean	+ 0.45150							
*0.059	P. B. M. 71	68 P. B. M.		Dir	+ 1.6705	+0.35	0.2	0.6	222.0925	728.656	+0.05	F.
				Rev	+ 1.6712	−0.35						F.
				Mean	+ 1.67085							

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*0.076	Zero of S. S. gauge	71 P. B. M.		Rev	− 7.33340				214.7583	704.594	−0.82	F.
*0.062	Zero of U. S. gauge	S. S. gauge		Dir	+ 0.15550				214.9138	705.104	−0.80	F.
*0.541	P. B. M. 72	71 P. B. M.		Dir	+21.8048	+0.65	0.4	0.8	243.9006	800.206	+2.64	F.
				Rev	+21.8061	−0.65						F.
				Mean	+21.80545							
*......	City datum, St. Paul	72 P. B. M.			−25.96880				217.9318	715.006	+2.64	F.
1.505	P. B. M. 73	70 P. B. M.	2.62	Dir	− 1.3871	+0.70	0.5	0.8	219.4865	720.107	−0.26	F.
				Rev	− 1.3857	−0.70						F.
				Mean	− 1.38640							
*0.014	T. B. M. 2	73 P. B. M.		Dir	+ 0.5103	+0.15	0.1	0.8	219.9970	721.781	−0.20	F.
				Rev	+ 0.5106	−0.15						F.
				Mean	+ 0.51045							
*0.014	P. B. M. 74	2 T. B. M.		Dir	+ 0.7091	−0.15	0.1	0.8	220.7060	724.108	−0.12	F.
				Rev	+ 0.7088	+0.15						F.
				Mean	+ 0.70895							
0.818	T. B. M. 3	73 P. B. M.	3.44	1. Dir	+ 1.7284	+1.95	0.5	0.9	221.2170	725.784	−0.05	F.
				1. Rev	+ 1.7319	−1.55						F.
				2. Dir	+ 1.7300	+0.35						F.
				2. Rev	+ 1.7311	−0.75						F.
				Mean	+ 1.73035							
1.150	P. B. M. 75	3 T. B. M.	4.59	1. Dir	− 2.2824	+3.75	0.8	1.2	218.9381	718.807	−0.32	F.
				1. Rev	− 2.2772	−1.45						F.
				2. Dir	− 2.2779	−0.75						F.
				2. Rev	− 2.2771	−1.55						F.
				Mean	− 2.27865							
*0.026	T. B. M. 4	75 P. B. M.		Dir	+ 0.0975	−0.35	0.2	1.2	219.0353	718.626	−0.31	M.
				Rev	+ 0.0968	+0.35						M.
				Mean	+ 0.09715							
*0.024	P. B. M. 76	4 T. B. M.		1. Dir	+ 1.1204	−0.23	0.1	1.2	220.1556	722.302	−0.18	M.
				1. Rev	+ 1.1201	+0.07						M.
				2. Dir	+ 1.1200	+0.17						M.
				Mean	+ 1.12017							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.120	T. B. M. 5	75 P. B. M.	5.71	1. Dir	+ 1.5395	− 1.22	0.8	1.5	220.4766	723.355	−0.14	M.
				1. Rev	+ 1.5358	+ 2.48						M.
				2. Dir	+ 1.5422	− 3.92						M.
				2. Rev	+ 1.5380	+ 0.28						M.
				3. Dir	+ 1.5371	+ 1.18						M.
				3. Rev	+ 1.5371	+ 1.18						M.
				Mean	+ 1.53828							
1.446	T. B. M. 6	5 T. B. M.	7.15	1. Dir	+ 2.9301 †	+10.16	0.8	1.7	223.4172	733.003	+0.21	M.
				1. Rev	+ 2.9359	+ 4.36						M.
				2. Dir	+ 2.9305 †	+ 9.76						M.
				2. Rev	+ 2.9418	− 1.54						M.
				3. Dir	+ 2.9239 †	+16.36						M.
				3. Rev	+ 2.9427	− 2.44						M.
				4. Dir	+ 2.9414	− 1.14						F.
				4. Rev	+ 2.9395	+ 0.76						F.
				Mean	+ 2.94026							
0.786	T. B. M. 7 and 7 *a*	6 T. B. M.	7.94	1. Dir	− 1.8239	+ 3.38	0.7	1.8	221.5964	727.029	−0.01	M.
				1. Rev	− 1.8166	− 3.92						M.
				2. Dir	− 1.8194	− 1.12						F.
				2. Rev	− 1.8223	+ 1.78						F.
				3. Dir	− 1.8258 †	+ 5.28						M.
				3. Rev	− 1.8261 †	+ 5.58						M.
				4. Dir	− 1.8219	+ 1.38						F.
				4. Rev	− 1.8190	− 1.52						F.
				Mean	− 1.82052							
0.865	T. B. M. 8	7 and *a* T. B. M.	8.80	1. Dir	+ 0.2830	− 1.49	0.6	1.9	221.8780	727.953	+0.02	F.
				1. Rev	+ 0.2789	+ 2.61						F.
				2. Dir	+ 0.2846	− 3.09						M.
				2. Rev	+ 0.2813	+ 0.21						M.
				3. Dir	+ 0.2784	+ 3.11						M.
				3. Rev	+ 0.2819	− 0.39						M.
				4. Dir	+ 0.2790	+ 2.51						M.
				4. Rev	+ 0.2850	− 3.49						M.
				Mean	+ 0.28151							

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0.695	T. B. M. 9	8 T. B. M.	9.50	1. Dir	− 3.0087	+ 3.27	0.8	2.1	218.8722	718.091	−0.33	M.
				1. Rev	− 3.0053	− 0.13						M.
				2. Dir	− 3.0042	− 1.23						M.
				2. Rev	− 3.0086	+ 3.17						M.
				3. Dir	− 3.0046	− 0.83						M.
				3. Rev	− 3.0012	− 4.23						M.
				Mean	− 3.00543							
1.667	P. B. M. 77	9 T. B. M.	11.17	Dir	+ 2.5026	− 0.30	0.2	2.1	221.3748	726.302	−0.04	F.
				Rev	+ 2.5020	+ 0.30						F.
				Mean	+ 2.50230							
*0.024	T. B. M. 10	77 P. B. M.		Dir	+ 1.5998	− 0.20	0.1	2.1	222.9746	731.551		F.
				Rev	+ 1.5994	+ 0.20					+0.17	M.
				Mean	+ 1.59960							
*0.026	P. B. M. 78	10 T. B. M.		Dir	− 0.3812	+ 0.05	0.0	2.1	222.5934	730.300		M.
				Rev	− 0.3811	− 0.05					+0.11	M.
				Mean	− 0.38115							
1.142	T. B. M. 11	77 P. B. M.	12.31	Dir	+ 6.0936	− 0.60	0.4	2.1	227.4685	740.294		F.
				Rev	+ 6.0924	+ 0.60					+0.69	F.
				Mean	+ 6.09300							
2.045	T. B. M. 12	11 T. B. M.	14.35	Dir	+ 5.3952	+ 1.25	0.8	2.3	232.8657	764.002		F.
				Rev	+ 5.3977	− 1.25					+1.45	F.
				Mean	+ 5.39645							
*0.032	P. B. M. 79	12 T. B. M.		Dir	− 1.1707	− 0.15	0.1	2.3	231.6946	760.100		M.
				Rev	− 1.1710	+ 0.15					+1.19	M.
				Mean	− 1.17085							
*0.032	P. B. M. 80	12 T. B. M.		Dir	+ 0.0480	− 0.20	0.1	2.3	232.9134	764.158		M.
				Rev	+ 0.0476	+ 0.20					+1.33	M.
				Mean	+ 0.04780							
*0.915	Old B. M. 12, also called Old P. B. M. 3	12 T. B. M.		1. Dir	−15.4724	− 3.28	0.8	2.4	217.3881	713.222	−0.51	F.
				1. Rev	−15.4782	+ 2.52						F.
				2. Dir	−15.4759	+ 0.22						F.
				2. Rev	−15.4762	+ 0.52						F.
				Mean	−15.47568							

† Rejected.

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
2.190	T. B. M. 13	12 T. B. M	16.54	Dir	+0.5249	+0.70	0.5	2.3	233.3913	765.726	+1.39	F.
				Rev	+0.5263	—0.70						F.
				Mean	+0.52560							
*0.014	P. B. M. 81	13 T. B. M		Dir	—0.0067	+0.05	0.0	2.3	233.3846	765.704	+1.39	F.
				Rev	—0.0066	—0.05						F.
				Mean	—0.00665							
0.970	T. B. M. 14	13 T. B. M	17.51	1. Dir	+2.1554	—1.95	0.5	2.4	235.5450	772.792	+1.65	F.
				1. Rev	+2.1527	+0.75						F.
				2. Dir	+2.1534	+0.05						F.
				2. Rev	+2.1523	+1.15						F.
				Mean	+2.15345							
*0.024	P. B. M. 83	14 T. B. M		Dir	—0.6234	—0.15	0.1	2.4	234.9214	770.746	+1.58	F.
				Rev	—0.6237	+0.15						F.
				Mean	—0.62355							
*0.032	P. B. M. 84	14 T. B. M		Dir	+0.5929	+0.05	0.0	2.4	236.1380	774.738	+1.73	F.
				Rev	+0.5930	—0.05						F.
				Mean	+0.59295							
1.024	T. B. M. 15 and 15*a*	14 T. B. M	18.54	Dir	+0.2690	—0.95	0.6	2.4	235.8131	773.672	+1.68	F.
				Rev	+0.2671	+0.95						F.
				Mean	+0.26805							
1.210	T. B. M. 16	15 and *a* T. B. M	19.75	Dir	—0.8382	—0.85	0.6	2.5	234.9739	770.919	+1.58	F.
				Rev	—0.8399	+0.85						F.
				Mean	—0.83905							
1.395	T. B. M. 17	16 T. B. M	21.14	Dir	—1.5378	+0.35	0.2	2.5	233.4363	765.874	+1.42	F.
				Rev	—1.5371	—0.35						F.
				Mean	—1.53745							

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1.435	T. B. M. 18 and 18a	17 T. B. M.	22.58	Dir	—4.1838	—0.70	0.5	2.6	229.2513	752.144	+0.90	F.
				Rev	—4.1852	+0.70						F.
				Mean	—4.18450							
1.618	T. B. M. 19	18 and a T. B. M.	24.19	Dir	—4.4042	+1.45	1.0	2.8	224.8480	737.697	+0.38	F.
				Rev	—4.4013	—1.45						F.
				Mean	—4.40275							
1.808	T. B. M. 20	19 T. B. M.	26.00	Dir	—5.1479	—0.20	0.1	2.8	219.6993	720.805	—0.24	F.
				Rev	—5.1483	+0.20						F.
				Mean	—5.14810							
*0.010	P. B. M. 85	20 T. B. M.		Dir	—2.0445	0.000	0.0	2.8	217.6546	714.096	—0.48	F.
				Rev	—2.0445	0.000						F.
				Mean	—2.04450							
*0.010	P. B. M. 86	20 T. B. M.		Dir	—0.8208	+0.05	0.0	2.8	218.8785	718.112	—0.33	F.
				Rev	—0.8207	—0.05						F.
				Mean	—0.82075							
2.495	T. B. M. 21	20 T. B. M.	28.50	1. Dir	—2.2545	+4.08	1.7	3.2	217.4486	713.420	—0.50	F.
				1. Rev	—2.2441	—6.32						F.
				2. Dir	—2.2493	—1.12						F.
				2. Rev	—2.2538	+3.38						F.
				Mean	—2.25042							
1.430	T. B. M. 22	21 T. B. M.	29.93	1. Dir	—0.0234	+3.18	1.1	3.4	217.4284	713.354	—0.50	F.
				1. Rev	—0.0171	—3.12						F.
				2. Dir	—0.0179	—2.32						F.
				2. Rev	—0.0225	+2.28						F.
				Mean	—0.02022							
1.145	P. B. M. 87	22 T. B. M.	31.07	Dir	—0.5231	+0.75	0.5	3.5	216.9060	711.640	—0.57	F.
				Rev	—0.5216	—0.75						F.
				Mean	—0.52235							
*0.098	Old B. M. 36	87 P. B. M.		Dir	—2.7199	—0.15	0.1	3.5	214.1856	702.715	—0.89	F.
				Rev	—2.7202	+0.15						F.
				Mean	—2.72005							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V.	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
0.203	Old B. M. 23, also called Old P. B. M. 4	87 P. B. M	31.28	1. Dir	+0.8893	−1.40	0.3	3.5	217.7940	714.554	−0.46	F.
				1. Rev	+0.8876	+0.30						F.
				2. Dir	+0.8873	+0.60						F.
				2. Rev	+0.8874	+0.50						F.
				Mean	+0.88790							
1.815	T. B. M. 23	23 Old B. M	33.09	Dir	−0.1341	−0.20	0.1	3.5	217.6597	714.113	−0.48	F.
				Rev	−0.1345	+0.20						F.
				Mean	−0.1343							
1.108	T. B. M. 24 and 24*a*	23 T. B. M	34.20	1. Dir	+0.3442	−0.43	0.8	3.6	218.0035	715.241	−0.44	M.
				1. Rev	+0.3471	−3.33						M.
				2. Dir	+0.3326†	+1.17						M.
				2. Rev	+0.3433	+0.47						M.
				3. Dir	+0.3373	+6.47						M.
				3. Rev	+0.3433	+0.47						M.
				4. Dir	+0.3448	−1.03						F.
				4. Rev	+0.3464	−2.63						F.
				Mean	+0.34377							
*0.050	P. B. M. 88	24 and *a* T. B. M		Dir	−1.0420	−0.10	0.1	3.6	216.9613	711.822	−0.56	M.
				Rev	−1.0422	+0.10						M.
				Mean	−1.04210							
*0.050	P. B. M. 89	24 and *a* T. B. M		Dir	+0.1791	+0.25	0.2	3.6	218.1828	715.829	−0.42	M.
				Rev	+0.1796	−0.25						M.
				Mean	+0.17935							
*0.435	P. B. M. 96	24 and *a* T. B. M		Dir	−1.2117	−0.20	0.1	3.6	216.7914	711.264	−0.58	F.
				Rev	−1.2121	+0.20						F.
				Mean	−1.21190							

*0.932	P. B. M. 97	96 P. B. M.		Dir	+1.1177	+0.80	0.5	3.6	217.9101	714.935	—0.45	F.
				Rev	+1.1193	—0.80						F.
				Mean	+1.11850							
*0.014	U. S. gauge, zero of (Hastings)	97 P. B. M.		Dir	—7.4861	—0.10	0.1	3.6	210.4230	690.370	—1.33	F.
				Rev	—7.4863	+0.10						F.
				Mean	—7.4862							
0.780	T. B. M. 25	24 and a T. B. M	34.98	Dir	+2.5543	+1.20	0.8	3.6	220.5593	723.626	—0.13	M.
				Rev	+2.5567	—1.20						M.
				Mean	+2.55550							
1.483	T. B. M. 26	25 T. B. M.	36.46	Dir	+1.6087	—1.80	1.2	3.8	222.1664	728.899	+0.06	F.
				Rev	+1.6051	+1.80						F.
				Mean	+1.6069							
*0.024	P. B. M. 90	26 T. B. M.		Dir	+1.0751	0.00	0.0	3.8	223.2416	732.427	+0.18	F.
				Rev	+1.0751	0.00						F.
				Mean	+1.07510							
1.709	T. B. M. 27	26 T. B. M.	38.17	Dir	—3.2415	—0.70	0.5	3.9	218.9238	718.260	—0.32	F.
				Rev	—3.2429	+0.70						F.
				Mean	—3.24220							
0.114	T. B. M. 28	27 P. B. M.	38.28	Dir	+0.9576	—0.10	0.1	3.9	219.8814	721.402	—0.21	F.
				Rev	+0.9574	+0.10						F.
				Mean	+0.95750							
*0.015	P. B. M. 91	28 T. B. M.		Dir	—1.8800	—0.15	0.1	3.9	218.0010	715.233	—0.44	F.
				Rev	—1.8803	+0.15						F.
				Mean	—1.88015							
1.411	T. B. M. 29 and 29a	28 T. B. M.	39.70	Dir	—2.2693	+1.05	0.7	3.9	217.6129	713.959	—0.48	F.
				Rev	—2.2672	—1.05						F.
				Mean	—2.26825							
1.362	T. B. M. 30	29 and a P. B. M	41.05	Dir	—2.4948	+1.05	0.7	4.0	215.1188	705.777	—0.77	F.
				Rev	—2.4927	—1.05						F.
				Mean	—2.49375							

† Rejected.

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Red cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
*0.014	P. B. M. 92	30 T. B. M.		Dir	+0.4973	0.00	0.0	4.0	215.6162	707.409	—0.71	F.
				Rev	+0.4973	0.00						F.
				Mean	+0.4973							
*0.014	P. B. M. 93	30 T. B. M.		Dir	+1.7145	+0.10	0.1	4.0	216.8336	711.403	—0.57	F.
				Rev	+1.7147	—0.10						F.
				Mean	+1.71460							
2.000	T. B. M. 31	30 T. B. M.	43.06	1. Dir	+0.8897	—4.73	1.3	4.2	216.0039	708.681	—0.68	F.
				1. Rev	+0.8813	+3.67						F.
				2. Dir	+0.8824	+2.57						F.
				2. Rev	+0.8865	—1.53						F.
				Mean	+0.88497							
1.840	T. B. M. 32	31 T. B. M.	44.90	Dir	—0.7295	+0.60	0.4	4.2	215.2749	706.289	—0.76	F.
				Rev	—0.7283	—0.60						F.
				Mean	—0.72890							
*0.024	P. B. M. 94	32 T. B. M.		Dir	—1.9218	+0.15	0.1	4.2	213.3530	699.983	—0.99	F.
				Rev	—1.9215	—0.15						F.
				Mean	—1.92165							
0.024	P. B. M. 95	32 T. B. M.		Dir	—0.7035	+0.15	0.1	4.2	214.5715	703.981	—0.84	W.
				Rev	—0.7032	—0.15						
				Mean	—0.70335							
0.644	T. B. M. 33	32 T. B. M.	45.54	1. Dir	—0.3820	+1.55	0.4	4.3	214.8944	705.040	—0.81	F.
				1. Rev	—0.3801	—0.35						F.
				2. Dir	—0.3807	+0.25						W.
				2. Rev	—0.3790	—1.45						W.
				Mean	—0.38045							

0.920	T. B. M. 34	33 T. B. M.	46.46	1. Dir	—0.6993	—1.00	0.4	4.3	214.1940	702.743	—0.89	F.
				1. Rev	—0.7026	+2.30						F.
				2. Dir	—0.6995	—0.80						F.
				2. Rev	—0.7004	+0.10						F.
				3. Div	—0.6997	—0.60						F.
				Mean	—0.7003							
1.316	T. B. M. 35	34 T. B. M.	47.78	Dir	+0.3352	—1.65	1.1	4.4	214.5276	703.837	—0.84	F.
				Rev	+0.3319	+1.65						F.
				Mean	+0.33355							
1,048	T. B. M. 36 and 36a	35 T. B. M.	48.83	Dir	—0.1858	+0.50	0.3	4.4	214.3423	703.229	—0.87	J.
				Rev	—0.1848	—0.50						J.
				Mean	—0.18530							
0.670	T. B. M. 37	36 and a T. B. M.	49.50	Dir	—1.0782	+0.90	0.6	4.4	213.2649	699.694	—1.00	F.
				Rev	—1.0764	—0.90						F.
				Mean	—1.0773							
*0.028	P. B. M. 98	37 T. B. M.		Dir	+0.3709	+0.05	0.0	4.4	213.6359	700.911	—0.95	F.
				Rev	+0.3710	—0.05						F.
				Mean	+0.37095							
*0.028	P. B. M. 99	37 T. B. M.		Dir	+1.5894	+0.15	0.1	4.4	214.8546	704.910	—0.81	F.
				Rev	+1.5897	—0.15						F.
				Mean	+1.58955							
0.984	T. B. M. 38	37 T. B. M.	50.48	Dir	+1.1906	+0.10	0.1	4.4	214.4557	703.601	—0.86	F.
				Rev	+1.1908	—0.10						F.
				Mean	+1.19070							
1.865	T. B. M. 39	38 T. B. M.	52.34	Dir	+1.3258	—1.00	0.7	4.5	215.7807	707.948	—0.70	F.
				Rev	+1.3238	+1.00						F.
				Mean	+1.32480							
*0.512	Recent B. M. (probably old B. M. 15 ?)	39 T. B. M.		Dir	—2.7960	—0.70	0.5	4.5	212.9836	698.771	—1.04	F.
				Rev	—2.7974	+0.70						F.
				Mean	—2.7967							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used=3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V.	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.066	T. B. M. 40	39 T. B. M.	53.40	Dir	+2.3422	−1.40	0.9	4.6	218.1218	715.629	−0.42	J.
				Rev	+2.3394	+1.40						J.
				Mean	+2.3408							
0.595	T. B. M. 41	40 T. B. M.	54.01	1. Dir	+0.8477	−4.29	0.7	4.6	218.9653	718.397	−0.32	J.
				1. Rev	+0.8420	+1.41						J.
				2. Dir	+0.8414	+2.01						J.
				2. Rev	+0.8477	−4.29						J.
				3. Dir	+0.8428	+0.61						J.
				3. Rev	+0.8397	+3.71						J.
				4. Dir	+0.8424	+1.01						J.
				4. Rev	+0.8436	−0.19						J.
				Mean	+0.84341							
0.747	T. B. M. 42 and 42*a*	41 T. B. M.	54.75	Dir	+1.5434	−0.70	0.5	4.7	220.5082	723.459	−0.14	J.
				Rev	+1.5420	+0.70						J.
				Mean	+1.54270							
*0.249	T. B. M. 47	42 and *a* T. B. M.		Dir	−7.2471	+0.65	0.4	4.7	213.2608	699.681	−1.00	F.
				Rev	−7.2458	−0.65						F.
				Mean	−7.24645							
*0.008	P. B. M. 100	47 T. B. M.		Dir	+1.3739	+0.05	0.0	4.7	214.6350	704.189	−0.83	F.
				Rev	+1.3740	−0.05						F.
				Mean	+1.37395							
*0.008	P. B. M. 101	47 T. B. M.		Dir	+2.5909	−0.15	0.1	4.7	215.8519	708.182	−0.69	F.
				Rev	+2.5906	+0.15						F.
				Mean	+2.59075							
0.860	T. B. M. 43	42 and *a* T. B. M.	55.61	Dir	+2.2398	+0.95	0.6	4.7	222.7492	730.811	+0.18	J.
				Rev	+2.2417	−0.95						J.
				Mean	+2.24075							
1.122	T. B. M. 44 and 44*a*	43 T. B. M.	56.73	Dir	+3.4995	−0.30	0.2	4.7	226.2488	742.203	+0.55	J.

				Rev	+3.4989	+0.30						J.
				Mean	+3.49920							
*0.027	T. B. M. 45	44 and a T. B. M.		Dir	+0.3072	+0.10	0.1	4.7	226.5561	743.301	+0.58	J.
				Rev	+0.3074	−0.10						J.
				Mean	+0.30730							
*0.021	P. B. M. 102	45 T. B. M.		Dir	−0.2098	+0.30	0.2	4.7	226.3466	742.614	+0.56	J.
				Rev	−0.2092	−0.30						J.
				Mean	−0.20950							
*0.021	P. B. M. 103	45 T. B. M.		1. Dir	+1.0060	−0.67	0.2	4.7	227.5625	746.603	+0.70	J.
				1. Rev	+1.0055	+0.73						J.
				2. Dir	+1.0058	+0.43						J.
				2. Rev	+1.0067	−0.47						J.
				Mean	+1.00623							
1.140	T. B. M. 46	44 and a T. B. M.	57.87	1. Dir	+0.9437	−2.47	1.1	4.8	227.1901	745.381	+0.65	J.
				1. Rev	+0.9367	+4.53						J.
				2. Dir	+0.9428	−1.57						J.
				2. Rev	+0.9417	−0.47						J.
				Mean	+0.94123							
*0.018	P. B. M. 104	46 T. B. M		Div	−1.5009	−0.15	0.1	4.8	225.6889	740.456	+0.48	J.
				Rev	−1.5012	+0.15						J.
				Mean	−1.50105							
*0.018	P. B. M. 105	46 T. B. M		Dir	−0.2790	+0.05	0.0	4.8	226.9112	744.466	+0.62	J.
				Rev	−0.2789	−0.05						J.
				Mean	−0.27895							
2,575	T. B. M. 48	46 T. B. M	60.45	Dir	−0.7869	+1.15	0.8	4.9	226.4043	742.803	+0.57	F.
				Rev	−0.7846	−1.15						F.
				Mean	−0.78575							
1.825	T. B. M. 49	48 T. B. M	62.27	1. Dir	−4.2539	+6.42	1.1	5.0	222.1563	728.866	+0.06	J.
				1. Rev	−4.2434	−4.08						J.
				2. Dir	−4.2427	−4.78						J.
				2. Rev	−4.2479	+0.42						J.
				3. Dir	−4.2487	+1.22						J.
				3. Rev	−4.2483	+0.82						J.
				Mean	−4.24748							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.870	T. B. M. 50	49 T. B. M	64.14	Dir	+17.1339	+1.05	0.7	5.1	239.2933	785.090	+2.09	J.
				Rev	+17.1360	−1.05						J.
				Mean	+17.13495							
0.334	T. B. M. 51	50 T. B. M	64.48	Dir	−27.1927	−0.30	0.2	5.1	212.0971	695.863	−1.14	J.
				Rev	−27.1933	+0.30						J.
				Mean	−27.19300							
*0.014	P. B. M. 106	51 T. B. M		Dir	− 0.3232	−0.15	0.1	5.1	211.7737	694.802	−1.18	J.
				Rev	− 0.3235	+0.15						J.
				Mean	− 0.32335							
*0.014	P. B. M. 107	51 T. B. M		Dir	+ 0.8999	+0.05	0.0	5.1	212.9971	698.816	−1.04	J.
				Rev	+ 0.9000	−0.05						J.
				Mean	+ 0.89995							
1.240	T. B. M. 52	51 T. B. M	65.72	Dir	+ 0.4446	+0.20	0.1	5.1	212.5419	697.322	−1.08	F.
				Rev	+ 0.4450	−0.20						F.
				Mean	+ 0.44480							
0.438	T. B. M. 53	52 T. B. M	66.16	Dir	− 0.1033	+0.35	0.2	5.1	212.4390	696.985	−1.10	F.
				Rev	− 0.1026	−0.35						F.
				Mean	− 0.10295							
*0.016	P. B. M. 108	53 T. B. M		Dir	− 0.8216	−0.05	0.0	5.1	211.6172	694.288	−1.19	F.
				Rev	− 0.8217	+0.05						F.
				Mean	− 0.82165							
*0.016	P. B. M. 109	53 T. B. M		Dir	+ 0.3948	−0.10	0.1	5.1	212.8837	698.280	−1.06	F.
				Rev	+ 0.3946	+0.10						F.
				Mean	+ 0.39470							

0.975	T. B. M. 54	53 T. B. M	67.13	1. Dir	— 1.4521	—4.05	1.0	5.2	210.9826	692.206	—1.27	F.
				1. Rev	— 1.4595	+3.35						F.
				2. Dir	— 1.4558	—0.35						F.
				2. Rev	— 1.4572	+1.05						F.
				Mean	— 1.45615							
1.040	T. B. M. 55	54 T. B. M	68.17	Dir	+ 1.9035	—0.25	0.2	5.2	212.8861	698.451	—1.05	F.
				Rev	+ 1.9030	+0.25						F.
				Mean	+ 1.90325							
1.555	T. B. M. 56	55 T. B. M	69.72	1. Dir	— 0.4343	—2.97	0.9	5.3	212.4488	697.017	—1.10	F.
				1. Rev	— 0.4405	+3.23						F.
				2. Dir	— 0.4363	—0.97						F.
				2. Rev	— 0.4380	+0.73						F.
				Mean	— 0.43727							
*0.010	P. B. M. 110	56 T. B. M		Dir	— 0.9975	+0.05	0.0	5.3	211.4532	693.750	—1.21	F.
				Rev	— 0.9954	—0.05						F.
				Mean	— 0.99545							
*0.010	P. B. M. 111	56 T. B. M		Dir	+ 0.2142	—0.05	0.0	5.3	212.6630	697.720	—1.07	F.
				Rev	+ 0.2141	+0.05						F.
				Mean	+ 0.21415							
0.520	P. B. M. 113	56 T. B. M	70.25	Dir	+ 0.2076	—0.45	0.3	5.3	212.6560	697.697	—1.07	F. & J.
				Rev	+ 0.2067	+0.45						F. & J.
				Mean	+ 0.20715							
*0.275	P. B. M. 112	113 P. B. M		Dir	+ 3.1852	+0.20	0.1	5.3	215.8417	708.148	—0.69	F.
				Rev	+ 3.1856	—0.20						F.
				Mean	+ 3.18540							
*0.212	U. S. gauge, zero of (Redwing)	113 P. B. M		Dir	— 3.6723	+1.40	0.9	5.3	208.9846	685.651	—1.51	F.
				Rev	— 3.6695	—1.40						F.
				Mean	— 3.67090							
1.256	T. B. M. 57	113 P. B. M	71.50	1. Dir	+ 3.1760	+3.70	1.0	5.4	215.8360	708.133	—0.69	J.
				1. Rev	+ 3.1839	—3.30						J.
				2. Dir	+ 3.1800	+0.60						J.
				2. Rev	+ 3.1816	—1.00						J.
				Mean	+ 3.18060							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with asterisk are not in main line of levels. The value of one meter used = 3.2808693.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.368	T. B. M. 58	57 T. B. M	72.87	Dir	+ 6.0459	−0.25	0.2	5.4	221.8833	727.970	+0.02	J.
				Rev	+ 6.0454	+0.25						J.
				Mean	+ 6.04565							
*0.255	P. B. M. 114	58 T. B. M		1. Dir	− 3.2267	+0.28	0.3	5.4	218.6565	717.383	−0.36	J.
				1. Rev	− 3.2253	−1.12						J.
				2. Dir	− 3.2271	+0.68						J.
				2. Rev	− 3.2266	+0.18						J.
				Mean	− 3.22642							
*0.260	P. B. M. 115	58 T. B. M		Dir	− 2.0106	−0.75	0.5	5.4	219.8717	721.370	−0.21	J.
				Rev	− 2.0111	+0.75						J.
				Mean	− 2.01135							
0.678	T. B. M. 59	58 T. B. M	73.54	1. Dir	−10.8095	−1.73	0.7	5.4	211.0708	692.496	−1.26	J.
				1. Rev	−10.8131	+1.87						J.
				2. Rev	−10.8111	−0.13						J.
				Mean	−10.81123							
1.654	T. B. M. 60	59 T. B. M	75.20	Dir	+ 0.0270	+0.55	0.4	5.4	211.0983	692.586	−1.26	J.
				Rev	+ 0.0281	−0.55						
				Mean	+ 0.02755							
1.147	T. B. M. 61	60 T. B. M	76.40	Dir	− 0.2971	−2.05	1.4	5.6	210.7992	691.605	−1.30	F.
				Rev	− 0.3012	+2.05						F.
				Mean	− 0.29915							
0.417	Old B. M. 32	61 T. B. M	76.77	Dir	+ 0.0488	+0.70	0.5	5.6	210.8487	691.767	1.29	F.
				Rev	+ 0.0502	−0.70						F.
				Mean	+ 0.0495							

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*0.074	P. B. M. 116	32 B. M		Dir	+ 1.4682	−0.05	0.0	5.6	212.3170	696.584	−1.11	F.
				Rev	+ 1.4681	+0.05						F.
				Mean	+ 1.46815							
*0.074	P. B. M. 117	32 B. M		Dir	+ 2.6842	+0.20	0.1	5.6	213.5334	700.575	−0.96	F.
				Rev	+ 2.6846	−0.20						F.
				Mean	+ 2.68440							
1.027	Old B. M	32 B. M	77.80	Dir	+ 0.4436	−0.30	0.2	5.7	211.2920	693.221	−1.24	F.
				Rev	+ 0.4430	+0.30						F.
				Mean	+ 0.44330							
0.645	Old B. M. 33	B. M., old	78.44	Dir	− 0.1990	−0.60	0.4	5.7	211.0924	692.567	−1.26	F.
				Rev	− 0.2002	+0.60						F.
				Mean	− 0.19960							
0.626	T. B. M. 62	33 B. M	79.05	Dir	+ 1.9283	+0.10	0.1	5.7	213.0210	698.894	−1.02	F.
				Rev	+ 1.9285	−0.10						F.
				Mean	+ 1.92840							
*0.016	P. B. M. 118	62 T. B. M		Dir	− 0.7407	−0.15	0.1	5.7	212.2801	696.463	−1.12	F.
				Rev	− 0.7410	+0.15						F.
				Mean	− 0.74085							
*0.016	P. B. M. 119	62 T. B. M		Dir	+ 0.4782	+0.05	0.0	5.7	213.4993	700.463	−0.98	F.
				Rev	+ 0.4783	−0.05						F.
				Mean	+ 0.47825							
0.374	T. B. M. 63	62 T. B. M	79.43	Dir	− 1.1269	+0.20	0.1	5.7	211.8942	695.197	−1.17	F.
				Rev	− 1.1265	−0.20						F.
				Mean	− 1.12670							
1.525	T. B. M. 64, same as old B. M., 36	63 T. B. M	80.95	Dir	+ 0.1670	−2.00	1.3	5.8	212.0502	695.738	−1.14	F.
				Rev	+ 0.1630	+2.00						F.
				Mean	+ 0.16500							
1.800	T. B. M. 65	64 T. B. M	82.75	1. Dir	+ 0.1103	−4.15	1.0	5.9	212.1654	696.087	−1.13	J.
				1. Rev	+ 0.1048	+1.35						J.
				2. Dir	+ 0.1034	+2.75						J.
				2. Rev	+ 0.1061	+0.05						J.
				Mean	+ 0.10615							

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Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V.	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			Km.		Meters.	Mm.	Mm.	Mm.	Meters.	Feet.	Mm.	
*0.041	P. B. M. 120	65 T. B. M		Dir	−0.4195	−0.20	0.1	5.9	211.7456	694.710	−1.18	J.
				Rev	−0.4199	+0.20						J.
				Mean	−0.41970							
*0.041	P. B. M. 121	65 [illegible]. B. M		Dir	+0.7998	0.00	0.0	5.9	212.9653	698.711	−1.04	J.
				Rev	+0.7998	0.00						J.
				Mean	+0.79980							
1.105	T. B. M. 66	65 T. B. M	83.86	Dir	−1.0931	+1.60	1.1	6.0	211.0737	692.505	−1.28	F.
				Rev	−1.0899	−1.60						F.
				Mean	−1.0915							
1.308	T. B. M. 67	66 T. B. M	85.18	Dir	−0.2340	+1.95	1.3	6.1	210.8417	691.744	−1.29	F.
				Rev	−0.2301	−1.95						F.
				Mean	−0.23205							
1.054	T. B. M. 68	67 T. B. M	86.23	Dir	−0.1134	+1.70	1.1	6.2	210.7300	691.378	−1.30	F.
				Rev	−0.1100	−1.70						F.
				Mean	−0.11170							
0.915	T. B. M. 69	68 T. B. M	87.15	Dir	−0.2650	−1.60	0.7	6.2	210.4633	690.503	−1.33	J.
				Rev	−0.2693	+2.70						J.
				Dir	−0.2669	+0.30						F.
				Rev	−0.2652	−1.40						F.
				Mean	−0.26660							
1.107	T. B. M. 70	69 T. B. M	88.25	Dir	−0.3765	−1.45	1.0	6.3	210.0853	689.262	−1.38	F.
				Rev	−0.3794	+1.45						F.
				Mean	−0.37795							
0.885	T. B. M. 71	70 T. B. M	88.64	Dir	+0.6323	−0.80	0.5	6.3	210.7169	691.335	−1.30	J.
				Rev	+0.6307	+0.80						J.
				Mean	+0.63150							

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0.491	T. B. M. 72	71 T. B. M.	89.13	Dir	+2.1673	−0.10	0.1	6.3	212.8844	698.446	−1.05	F.
				Rev	+2.1671	+0.10						F.
				Mean	+2.16720							
*0.010	P. B. M. 122	72 T. B. M.		Dir	−1.0080	0.00	0.0	6.3	211.8762	695.138	−1.17	F.
				Rev	−1.0080	0.00						F.
				Mean	−1.00800							
*0.010	P. B. M. 123	72 T. B. M.		Dir	+0.2077	−0.05	0.0	6.3	213.0920	699.127	−1.02	F.
				Rev	+0.2076	+0.05						F.
				Mean	+0.20765							
0.760	T. B. M. 73	72 T. B. M.	89.89	Dir	−0.4233	−0.70	0.5	6.3	212.4603	697.054	−1.10	F.
				Rev	−0.4247	+0.70						F.
				Mean	−0.42400							
1.004	T. B. M. 74	73 T. B. M.	90.98	Dir	+7.6342	+1.35	0.9	6.4	220.0968	722.109	−0.19	J.
				Rev	+7.6369	−1.35						J.
				Mean	+7.63555							
1.492	T. B. M. 75	74 T. B. M.	92.47	Dir	−3.7969	−0.85	0.6	6.5	216.2986	709.647	−0.64	J.
				Rev	−3.7986	+0.85						J.
				Mean	−3.79775							
1.205	T. B. M. 76	75 T. B. M.	93.68	Dir	−1.2159	−1.75	1.2	6.6	215.0808	705.652	−0.79	F.
				Rev	−1.2194	+1.73						F.
				Mean	−1.21765							
*0.040	P. B. M. 124	76 T. B. M.		Dir	−1.7652	−0.15	0.1	6.6	213.3152	699.859	−0.99	F.
				Rev	−1.7655	+0.15						F.
				Mean	−1.76535							
*0.040	P. B. M. 125	76 T. B. M.		Dir	−0.5462	+0.15	0.1	6.6	214.5347	703.860	−0.84	F.
				Rev	−0.5459	−0.15						F.
				Mean	−0.54605							
1.030	T. B. M. 77	76 T. B. M.	94.71	Dir	−3.9236	+0.45	0.3	6.6	211.1572	692.779	−1.25	F.
				Rev	−3.9227	−0.45						F.
				Mean	−3.92315							

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Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	v	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.139	T. B. M. 78	77 T. B. M	95.85	Dir	+0.0433	+0.45	0.3	6.6	211.2009	692.922	—1.25	F.
				Rev	+0.0442	—0.45						F.
				Mean	+0.04375							
0.874	T. B. M. 79	78 T. B. M	96.72	Dir	+1.3253	+0.05	0.0	6.6	212.5264	697.271	—1.08	F.
				Rev	+1.3254	—0.05						F.
				Mean	+1.32535							
1.477	T. B. M. 80	79 T. B. M	98.20	Dir	—0.3289	—0.95	0.6	6.6	212.1965	696.189	—1.13	F.
				Rev	—0.3308	+0.95						F.
				Mean	—0.32985							
*0.118	P. B. M. 126	80 T. B. M		Dir	—0.1018	+0.35	0.2	6.6	212.0951	695.856	—1.14	F.
				Rev	—0.1011	—0.35						F.
				Mean	—0.10145							
*1.118	P. B. M. 127	80 T. B. M		Dir	+1.1132	+0.10	0.1	6.6	213.3100	699.842	—1.00	F.
				Rev	+1.1134	—0.10						F.
				Mean	+1.11330							
1.235	T. B. M. 81	80 T. B. M	99.43	Dir	—0.1306	—0.80	0.5	6.6	212.0651	695.758	—1.14	F.
				Rev	—0.1322	+0.80						F.
				Mean	—0.13140							
0.931	P. B. M. 123	81 T. B. M	100.37	Dir	+4.3171	—0.50	0.3	6.6	216.3822	709.922	—0.63	F.
				Rev	+4.3161	+0.50						F.
				Mean	+4.31660							
0.066	P. B. M. 129	128 P. B. M	100.43	Dir	+0.0282	—0.15	0.1	6.6	216.4103	710.014	—0.63	F.
				Rev	+0.0279	+0.15						F.
				Mean	+0.02805							

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*0.322	Old B. M.	129 P. B. M		Dir	—4.4533	+1.10	0.7	6.7	211.9576	695.405	—1.15	F.
				Rev	—4.4511	—1.10						F.
				Mean	—4.45220							
1.385	T. B. M. 82	129 P B. M	101.82	Dir	—3.8260	—0.35	0.2	6.6	212.5835	697.459	—1.08	F.
				Rev	—3.8267	+0.35						F.
				Mean	—3.82635							
2.003	T. B. M. 83 and 83 *a*	82 T. B. M	103.82	Dir	+5.4019	+6.70	1.6	6.8	217.9927	715.206	—0.44	J.
				Rev	+5.4135	—4.90						J.
				Dir	+5.4087	—0.10						
				Rev	+5.4103	—1.70						
				Mean	+5.40860							
*0.070	P. B. M. 130	83 and *a* T. B. M		Dir	—0.8742	+0.10	0.1	6.8	217.1185	712.337	—0.54	F.
				Rev	—0.8740	—0.10						F.
				Mean	—0.87410							
*0.070	P. B. M. 131	83 and *a* T. B. M		Dir	+0.3467	+0.10	0.1	6.8	218.3396	716.344	—0.39	F.
				Rev	+0.3469	—0.10						F.
				Mean	+0.3468							
1.620	T. B. M. 84	83 and *a* T. B. M.	105.44	Dir.	—3.2218	—5.30	1.3	6.9	214.7652	704.617	—0.82	J.
				Rev.	—3.2285	+1.40						J.
				Dir.	—3.2271	0.00						J.
				Rev	—3.2310	+3.90						J.
				Mean	—3.22710							
1.190	T. B. M. 85	84 T. B. M	106.63	Dir	—2.1393	+2.75	0.9	7.0	212.6284	697.606	—1.07	F.
				Rev	—2.1331	—3.45						F.
				Dir	—2.1378	+1.25						F.
				Rev	—2.1360	—0.55						F.
				Mean	—2.13655							
1.506	T. B. M. 86	85 T. B. M.	108.14	Dir	+0.7812	+1.45	1.0	7.1	213.4112	700.174	—0.99	F.
				Rev	+0.7841	—1.45						F.
				Mean	+0.78265							
*0.043	P. B. M. 132	86 T. B. M		Dir	+0.2698	+0.30	0.2	7.1	213.6813	701.060	—0.95	J.
				Rev	+0.2704	—0.30						J.
				Mean	+0.27010							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V.	r ±	E +	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
2.010	T. B. M. 87	86 T. B. M	110.15	Dir	+ 0.1763	+4.35	1.7	7.3	213.5918	700.767	—0.96	J.
				Rev	+ 0.1880	—7.35						J.
				Dir	+ 0.1799	+0.75						J.
				Rev	+ 0.1784	+2.25						J.
				Mean	+ 0.18065							
*0.032	P. B. M. 133	87 T. B. M		Dir	+ 0.7118	+0.35	0.2	7.3	214.3041	703.104	—0.88	F.
				Rev	+ 0.7125	—0.35						F.
				Mean	+ 0.71215							
*0.032	P. B. M. 134	87 T. B. M		Dir	+ 1.9345	—0.10	0.1	7.3	215.5265	707.114	—0.73	F.
				Rev	+ 1.9343	+0.10						F.
				Mean	+ 1.93440							
2.630	T. B. M. 88	87 T. B. M	112.77	Dir	— 0.4074	+2.05	1.4	7.4	213.1864	699.437	—1.01	F.
				Rev	— 0.4033	—2.05						F.
				Mean	— 0.40535							
1.055	T. B. M. 89	88 T. B. M	113.83	Dir	+ 1.4289	+0.90	0.6	7.4	214.6164	704.128	—0.83	F.
				Rev	+ 1.4307	—0.90						F.
				Mean	+ 1.42980							
1.075	T. B. M. 90	89 T. B. M	114.91	Dir	— 0.7632	—0.70	0.5	7.4	213.8524	701.622	—0.93	F.
				Rev	— 0.7646	+0.70						F.
				Mean	— 0.76390							
*0.010	P. B. M. 135	90 T. B. M		Dir	+ 1.1583	—0.10	0.1	7.4	215.0108	705.422	—0.80	F.
				Rev	+ 1.1581	+0.10						F.
				Mean	+ 1.15820							
*0.010	P. B. M. 136	90 T. B. M		Dir	+ 2.3765	+0.15	0.1	7.4	216.2294	709.420	—0.64	F.
				Rev	+ 2.3768	—0.15						F.
				Mean	+ 2.37665							

1.285	T. B. M. 91	90 T. B. M	116.17	Dir	+ 0.8113	+1.50	1.0	7.5	214.6653	704.289	—0.83	F.
				Rev	+ 0.8143	—1.50						F.
				Mean	+ 0.81280							
1.618	T. B. M. 92	91 T. B. M	117.79	Dir	— 1.6440	—1.15	0.8	7.6	213.0200	698.891	—1.02	J.
				Rev.	— 1.6463	+1.15						J.
				Mean	— 1.64515							
*0.078	P. B. M. 137	92 T. B. M		Dir	+ 2.2640	+0.10	0.1	7.6	215.2843	706.320	—0.76	F.
				Rev.	+ 2.2642	—0.10						F.
				Mean	+ 2.26410							
0.870	T. B. M. 93	92 T. B. M	118.66	Dir	+ 1.4673	+1.15	0.8	7.6	214.4886	703.709	—0.86	J.
				Rev	+ 1.4696	—1.15						J.
				Mean	+ 1.46845							
*0.046	P. B. M. 138	93 T. B. M		Dir	+ 0.5352	+0.15	0.1	7.6	215.0240	705.466	—0.79	F.
				Rev	+ 0.5355	—0.15						F.
				Mean	+ 0.53535							
*0.046	P. B. M. 139	93 T. B. M		Dir	+ 1.7510	0.00	0.0	7.6	216.2398	709.455	—0.64	F.
				Rev.	+ 1.7510	0.00						F.
				Mean	+ 1.75100							
*0.036	Old B. M. "A"	93 T. B. M		Dir	+ 2.0233	+0.15	0.1	7.6	216.5123	710.349	—0.62	F.
				Rev.	+ 2.0236	—0.15						F.
				Mean	+ 2.02345							
1.526	T. B. M. 94	93 T. B. M	120.18	Dir	+ 7.3838	—0.65	1.7	7.8	221.8726	727.935	+0.02	F.
				Rev.	+ 7.3900	—6.85						F.
				Dir	+ 7.3789	+4.25						F.
				Rev.	+ 7.3799	+3.25						F.
				Mean	+ 7.38315							
1.950	T. B. M. 95	94 T. B. M	122.13	Dir	—10.0254	—0.85	0.6	7.8	211.8452	695.036	—1.17	J.
				Rev.	—10.0271	+0.85						J.
				Mean	—10.02625							
0.820	P. B. M. 140	95 T. B. M	122.95	Dir	+ 4.8142	—0.65	0.4	7.8	216.6593	710.831	—0.60	J.
				Rev.	+ 4.8129	+0.65						J.
				Mean	+ 4.81355							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V.	r ±	E +	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
2.010	T. B. M. 87	86 T. B. M	110.15	Dir	+ 0.1763	+4.35	1.7	7.3	213.5918	700.767	—0.96	J.
				Rev	+ 0.1880	—7.35						J.
				Dir	+ 0.1799	+0.75						J.
				Rev	+ 0.1784	+2.25						J.
				Mean	+ 0.18065							
*0.032	P. B. M. 133	87 T. B. M		Dir	+ 0.7118	+0.35	0.2	7.3	214.3041	703.104	—0.88	F.
				Rev	+ 0.7125	—0.35						F.
				Mean	+ 0.71215							
*0.032	P. B. M. 134	87 T. B. M		Dir	+ 1.9345	—0.10	0.1	7.3	215.5265	707.114	—0.73	F.
				Rev	+ 1.9343	+0.10						F.
				Mean	+ 1.93440							
2.630	T. B. M. 88	87 T. B. M	112.77	Dir	— 0.4074	+2.05	1.4	7.4	213.1864	699.437	—1.01	F.
				Rev	— 0.4033	—2.05						F.
				Mean	— 0.40535							
[illegible]	T. B. M. 89	88 T. B. M	113.83	Dir	+ 1.4289	+0.90	0.6	7.4	214.6164	704.128	—0.83	F.
				Rev	+ 1.4307	—0.90						F.
				Mean	+ 1.42980							
[illegible]	[illegible]	89 T. B. M	114.91	Dir	— 0.7632	—0.70	0.5	7.4	213.8524	701.622	—0.93	F.
				Rev	— 0.7646	+0.70						F.
				Mean	— 0.76390							
[illegible]	[illegible]	90 T. B. M		Dir	+ 1.1583	—0.10	0.1	7.4	215.0108	705.422	—0.80	F.
				Rev	+ 1.1581	+0.10						F.
				Mean	+ 1.15820							
[illegible]	[illegible]	90 T. B. M		Dir	+ 2.3765	+0.15	0.1	7.4	216.2294	709.420	—0.64	F.
				Rev	+ 2.3768	—0.15						F.
				Mean	+ 2.37665							

[illegible]	[illegible]	90 T. B. M	116.17	Dir	+ 0.8113	+1.50	1.0	7.5	214.6653	704.289	—0.83	F.
				Rev	+ 0.8143	—1.50						F.
				Mean	+ 0.81280							
[illegible]	[illegible]	91 T. B. M	117.79	Dir	— 1.6440	—1.15	0.8	7.6	213.0200	698.891	—1.02	J.
				Rev	— 1.6463	+1.15						J.
				Mean	— 1.64515							
*0.078	P. B. [illegible]	92 T. B. M		Dir	+ 2.2640	+0.10	0.1	7.6	215.2843	706.320	—0.76	F.
				Rev	+ 2.2642	—0.10						F.
				Mean	+ 2.26410							
[illegible]	[illegible] M. 93	92 T. B. M	118.66	Dir	+ 1.4673	+1.15	0.8	7.6	214.4886	703.709	—0.86	J.
				Rev	+ 1.4696	—1.15						J.
				Mean	+ 1.46845							
[illegible]	[illegible] 38	93 T. B. M		Dir	+ 0.5352	+0.15	0.1	7.6	215.0240	705.466	—0.79	F.
				Rev	+ 0.5355	—0.15						F.
				Mean	+ 0.53535							
*0.046	P. B. M. 139	93 T. B. M		Dir	+ 1.7510	0.00	0.0	7.6	216.2398	709.455	—0.64	F.
				Rev	+ 1.7510	0.00						F.
				Mean	+ 1.75100							
*0.036	Old B. M. "A"	93 T. B. M		Dir	+ 2.0233	+0.15	0.1	7.6	216.5123	710.349	—0.62	F.
				Rev	+ 2.0236	—0.15						F.
				Mean	+ 2.02345							
1.526	T. B. M. 94	93 T. B. M	120.18	Dir	+ 7.3838	—0.65	1.7	7.8	221.8726	727.935	+0.02	F.
				Rev	+ 7.3900	—6.85						F.
				Dir	+ 7.3789	+4.25						F.
				Rev	+ 7.3799	+3.25						F.
				Mean	+ 7.38315							
1.950	T. B. M. 95	94 T. B. M	122.13	Dir	—10.0254	—0.85	0.6	7.8	211.8452	695.036	—1.17	J.
				Rev	—10.0271	+0.85						J.
				Mean	—10.02625							
0.820	P. B. M. 140	95 T. B. M	122.95	Dir	+ 4.8142	—0.65	0.4	7.8	216.6593	710.831	—0.60	J.
				Rev	+ 4.8129	+0.65						J.
				Mean	+ 4.81355							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V.	r ±	E ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
2.010	T. B. M. 87	86 T. B. M	110.15	Dir	+ 0.1763	+4.35	1.7	7.3	213.5916	700.767	—0.96	J.
				Rev	+ 0.1880	—7.35						J.
				Dir	+ 0.1799	+0.75						J.
				Rev	+ 0.1784	+2.25						J.
				Mean	+ 0.18065							
*0.032	P. B. M. 133	87 T. B. M		Dir	+ 0.7118	+0.35	0.2	7.3	214.3041	703.104	—0.88	F.
				Rev	+ 0.7125	—0.35						F.
				Mean	+ 0.71215							
*0.032	P. B. M. 134	87 T. B. M		Dir	+ 1.9345	—0.10	0.1	7.3	215.5265	707.114	—0.73	F.
				Rev	+ 1.9343	+0.10						F.
				Mean	+ 1.93440							
2.630	T. B. M. 88	87 T. B. M	112.77	Dir	— 0.4074	+2.05	1.4	7.4	213.1864	699.437	—1.01	F.
				Rev	— 0.4033	—2.05						F.
				Mean	— 0.40535							
1.055	T. B. M. 89	88 T. B. M	113.83	Dir	+ 1.4289	+0.90	0.6	7.4	214.6164	704.128	—0.83	F.
				Rev	+ 1.4307	—0.90						F.
				Mean	+ 1.42980							
1.075	T. B. M. 90	89 T. B. M	114.91	Dir	— 0.7632	—0.70	0.5	7.4	213.8524	701.622	—0.93	F.
				Rev	— 0.7646	+0.70						F.
				Mean	— 0.76390							
*0.010	P. B. M. 135	90 T. B. M		Dir	+ 1.1583	—0.10	0.1	7.4	215.0108	705.422	—0.80	F.
				Rev	+ 1.1581	+0.10						F.
				Mean	+ 1.15820							
*0.010	P. B. M. 136	90 T. B. M		Dir	+ 2.3765	+0.15	0.1	7.4	216.2294	709.420	—0.64	F.
				Rev	+ 2.3768	—0.15						F.
				Mean	+ 2.37665							

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1.265	T. B. M. 91	90 T. B. M	116.17	Dir	+ 0.8113	+1.50	1.0	7.5	214.6653	704.289	—0.83	F.
				Rev	+ 0.8143	—1.50						F.
				Mean	+ 0.81280							
1.618	T. B. M. 92	91 T. B. M	117.79	Dir	— 1.6440	—1.15	0.8	7.6	213.0200	698.891	—1.02	J.
				Rev,	— 1.6463	+1.15						J.
				Mean	— 1.64515							
*0.078	P. B. M. 137	92 T. B. M		Dir	+ 2.2640	+0.10	0.1	7.6	215.2843	706.320	—0.76	F.
				Rev	+ 2.2642	—0.10						F.
				Mean	+ 2.26410							
0.870	T. B. M. 93	92 T. B. M	118.66	Dir	+ 1.4673	+1.15	0.8	7.6	214.4886	703.709	—0.86	J.
				Rev	+ 1.4696	—1.15						J.
				Mean	+ 1.46845							
*0.046	P. B. M. 138	93 T. B. M		Dir	+ 0.5352	+0.15	0.1	7.6	215.0240	705.466	—0.79	F.
				Rev	+ 0.5355	—0.15						F.
				Mean	+ 0.53535							
*0.046	P. B. M. 139	93 T. B. M		Dir	+ 1.7510	0.00	0.0	7.6	216.2308	709.455	—0.64	F.
				Rev	+ 1.7510	0.00						F.
				Mean	+ 1.75100							
*0.036	Old B. M. "A"	93 T. B. M		Dir	+ 2.0233	+0.15	0.1	7.6	216.5123	710.349	—0.62	F.
				Rev	+ 2.0236	—0.15						F.
				Mean	+ 2.02345							
1.526	T. B. M. 94	93 T. B. M	120.18	Dir	+ 7.3838	—0.65	1.7	7.8	221.8726	727.935	+0.02	F.
				Rev	+ 7.3900	—6.85						F.
				Dir	+ 7.3789	+4.25						F.
				Rev	+ 7.3799	+3.25						F.
				Mean	+ 7.38315							
1.950	T. B. M. 95	94 T. B. M	122.13	Dir	—10.0254	—0.85	0.6	7.8	211.8452	695.036	—1.17	J.
				Rev	—10.0271	+0.85						J.
				Mean	—10.02625							
0.820	P. B. M. 140	95 T. B. M	122.95	Dir	+ 4.8142	—0.65	0.4	7.8	216.6593	710.831	—0.60	J.
				Rev	+ 4.8129	+0.65						J.
				Mean	+ 4.81355							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used=3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
*0.154	Old B. M. "62¼"	140 P. B. M		Dir	—4.0090	+0.15	0.1	7.8	212.6500	697.677	—1.07	J.
				Rev	—4.0087	—0.15						J.
				Mean	—4.00885							
*0.219	Gauge zero of Wabasha River gauge	"62¼" B. M		Dir	—4.1573	+0.90	0.6	7.8	208.4931	684.039	—1.57	F.
				Rev	—4.1555	—0.90						F.
				Mean	—4.15640							
0.142	Old B. M. "E"	140 P. B. M.	123.10	Dir	—0.0367	—0.10	0.1	7.8	216.6225	710.710	—0.60	F.
				Rev	—0.0369	+0.10						F.
				Mean	—0.03680							
0.333	T. B. M. 96	"E" B. M.	123.43	Dir	—2.6714	—0.15	0.1	7.8	213.9506	701.944	—0.92	F.
				Rev	—2.6717	+0.15						F.
				Mean	—2.67155							
*0.012	P. B. M. 141	96 T. B. M		Dir	—1.0035	+0.10	0.1	7.8	212.9471	698.652	—1.04	F.
				Rev	—1.0033	—0.10						F.
				Mean	—1.00340							
*0.012	P. B. M. 142	96 T. B. M		Dir	+0.2069	+0.05	0.1	7.8	214.1576	702.623	—0.89	F.
				Rev	+0.2070	—0.05						F.
				Mean	+0.20695							
1.278	T. B. M. 97	96 T. B. M	124.71	Dir	—4.4818	—1.75	1.2	7.9	209.4666	687.233	—1.45	J.
				Rev	—4.4853	+1.75						J.
				Mean	—4.48355							
0.640	T. B. M. 98	97 T. B. M	125.35	Dir	+0.3284	+0.60	0.4	7.9	209.7956	688.312	—1.42	J.
				Rev	+0.3296	—0.60						J.
				Mean	+0.32900							

*0.035	Old B. M. "66"	98 T. B. M		Dir	+0.2009				209.9965	688.971	—1.39	J.
				Rev								J.
				Mean	+0.20090							J.
2.580	Old B. M. "O"	98 T. B. M	127.93	Dir	+4.5174	+1.50	1.0	8.0	214.3150	703.140	—0.87	J.
				Rev	+4.5204	—1.50						J.
				Mean	+4.51890							
0.056	P. B. M. 143	"O" B. M		Dir	—3.0015	+0.10	0.1	8.0	211.3133	693.291	—1.23	J.
				Rev	—3.0013	—0.10						J.
				Mean	—3.00140							
*0.038	P. B. M. 144	"O" B. M		Dir	—1.7877	+0.20	0.1	8.0	212.5273	697.274	—1.08	J.
				Rev	—1.7873	—0.20						J.
				Mean	—1.78750							
0.290	Old B. M. "N"	"O" B. M	128.22	Dir	—1.5698	+0.05	0.0	8.0	212.7451	697.989	—1.06	J.
				Rev	—1.5697	—0.05						J.
				Mean	—1.56975							
1.205	T. B. M. 99	"N" B. M.	129.42	Dir	+3.8015	—0.05	0.0	8.0	216.5470	710.462	—0.61	J.
				Rev	+3.8014	+0.05						J.
				Mean	+3.80145							
1.993	T. B. M. 100	99 T. B. M.	131.42	Dir	+2.4734	+0.90	0.6	8.0	219.0216	718.581	—0.31	F.
				Rev	+2.4752	—0.90						F.
				Mean	+2.47430							
0.675	T. B. M. 101	100 T. B. M.	132.09	Dir	—9.7728	+0.10	0.1	8.0	209.2477	686.514	—1.48	F.
				Rev	—9.7726	—0.10						F.
				Mean	—9.77270							
1.337	T. B. M. 102	101 T. B. M.	133.43	Dir	—0.0812	+0.70	0.5	8.1	209.1672	686.250	—1.43	F.
				Rev	—0.0798	—0.70						F.
				Mean	—0.08050							
*0.010	P. B. M. 145	102 T. B. M.		Dir	—0.6569	0.00	0.0	8.1	208.5102	684.095	—1.57	F.
				Rev	—0.6569	0.00						F.
				Mean	—0.65690							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used =3.2808693 feet.]

Length B. M. to B. M.	Bench marks	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
*0.010	P. B. M. 146	102 T. B. M		Dir	+0.5601	—0.20	0.1	8.1	209.7272	688.088	—1.42	F.
				Rev	+0.5597	+0.20						F.
				Mean	+0.55990							
1.602	T. B. M. 103	102 T. B. M	135.03	Dir	—0.5851	+0.15	0.1	8.1	208.5822	684.331	—1.58	F.
				Rev	—0.5848	—0.15						F.
				Mean	—0.58495							
0.512	T. B. M. 104	103 T. B. M	135.53	Dir	+3.0206	+0.20	0.1	8.1	211.6034	694.243	—1.20	F.
				Rev	+3.0210	—0.20						F.
				Mean	+3.02080							
*0.010	P. B. M. 147	104 T. B. M		Dir	+0.0012	—0.20	0.1	8.1	211.6044	694.246	—1.20	J.
				Rev	+0.0008	+0.20						J.
				Mean	+0.00100							
0.485	Old B. M. "1"	104 T. B. M	136.02	Dir	+1.9558	+0.80	0.5	8.1	213.5602	700.663	—0.96	J.
				Rev	+1.9574	—0.80						J.
				Mean	+1.95660							
0.640	Old B. M. "3"	"1" B. M	136.66	Dir	+0.5963	—0.35	0.2	8.1	214.1562	702.619	—0.89	J.
				Rev	+0.5956	+0.35						J.
				Mean	+0.59595							
*0.076	P. B. M. 148	"3" B. M		Dir	+1.5218	—0.05	0.0	8.1	215.6781	707.612	—0.71	J.
				Rev	+1.5217	+0.05						J.
				Mean	+1.52175							
0.930	Old B. M. "4"	"3" B. M	137.59	Dir	—0.7294	+1.85	1.2	8.1	213.4286	700.231	—0.98	J.
				Rev	—0.7257	—1.85						J.
				Mean	—0.72755							

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1.838	T. B. M. 105	"4" B. M.	138.92	Dir	—0.5354	—0.45	0.3	8.1	212.8926	698.473	—1.05	F.
				Rev	—0.5363	+0.45						F.
				Mean	—0.53585							
*0.048	P. B. M. 149	105 T. B. M		Dir	—0.7748	0.00	0.0	8.1	212.1178	695.931	—1.13	J.
				Rev	—0.7748	0.00						J.
				Mean	—0.77480							
*0.048	P. B. M. 150	105 T. B. M.		Dir	+0.4368	+0.35	0.2	8.1	213.3299	699.908	—0.90	J.
				Rev	+0.4375	—0.35						J.
				Mean	+0.43715							
1.025	T. B. M. 106	105 T. B. M	139.94	Dir	—0.8347	—0.50	0.3	8.1	212.0574	695.783	—1.14	J.
				Rev	—0.8357	+0.50						J.
				Mean	—0.83520							
1.145	T. B. M. 107	106 T. B. M	141.09	Dir	—0.4888	+0.45	0.3	8.1	211.5690	694.130	—1.20	J.
				Rev	—0.4879	—0.45						J.
				Mean	—0.48835							
1.170	T. B. M. 108	107 T. B. M	142.26	Dir	—1.5127	—0.50	0.3	8.1	210.0556	689.165	—1.38	F.
				Rev	—1.5137	+0.50						F.
				Mean	—1.51 20							
0.109	P. B. M. 151	108 T. B. M		1 Dir	—0.2050	+0.50	0.1	8.1	209.8510	688.494	—1.40	F.
				1 Rev	—0.2042	—0.30						F.
				2 Dir	—0.2046	+0.10						F.
				2 Rev	—0.2042	—0.30						F.
				Mean	—0.20450							
*0.109	P. B. M. 152	108 T. B. M		Dir	+1.0121	—0.20	0.1	8.1	211.0676	692.485	—1.26	F.
				Rev	+1.0117	+0.20						F.
				Mean	+1.01190							
1.610	T. B. M. 109	108 T. B. M	143.87	Dir	—0.9083	—0.25	0.2	8.2	209.0569	685.888	—1.50	F.
				Rev	—0.9988	+0.25						F.
				Mean	—0.99855							
1.748	T. B. M. 110	109 T. B. M.	145.61	Dir	+4.7122	—1.80	1.2	8.3	213.7679	701.345	—0.94	F.
				Rev	+4.7086	+1.80						F.
				Mean	+4.71040							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.345	T. B. M. 111	110 T. B. M.	146.96	Dir	−3.5422	−1.55	1.0	8.3	210.2237	689.716	−1.36	J.
				Rev	−3.5453	+1.55						J.
				Mean	−3.54375							
0.750	T. B. M. 112	111 T. B. M.	147.61	Dir	+2.8868	+0.35	0.2	8.3	213.1112	699.190	−1.02	J.
				Rev	+2.8875	−0.35						J.
				Mean	+2.88715							
0.985	T. B. M. 113	112 T. B. M.	148.60	Dir	+1.8516	−0.95	0.6	8.3	214.9620	705.262	−0.80	J.
				Rev	+1.8497	+0.95						J.
				Mean	+1.85065							
1.027	T. B. M. 114	113 T. B. M.	149.62	Dir	−2.7823	−0.55	0.4	8.3	212.1789	696.131	−1.13	J.
				Rev	−2.7834	+0.55						J.
				Mean	−2.78285							
*0.030	P. B. M. 153	114 T. B. M.		Dir	−1.8208	0.00	0.0	8.3	210.3579	690.157	−1.34	J.
				Rev	−1.8208	0.00						J.
				Mean	−1.82080							
*0.030	P. B. M. 154	114 T. B. M.		Dir	−0.5997	+0.35	0.2	8.3	211.5794	694.164	−1.20	J.
				Rev	−0.5990	−0.35						J.
				Mean	−0.59035							
1.960	T. B. M. 115 and 115 a	114 T. B. M.	151.58	Dir	−2.9648	+0.40	0.3	8.3	209.2141	686.404	−1.48	F.
				Rev	−2.9640	−0.40						F.
				Mean	−2.96440							
1.423	T. B. M. 116	115 a T. B. M	153.01	Dir	+1.1280	−0.30	0.2	8.3	210.3420	690.105	−1.34	F.
				Rev	+1.1274	+0.30						F.
				Mean	+1.12770							

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1.185	T. B. M. 117	116 T. B. M.	154.19	Dir	−0.5442	−1.90	1.2	8.5	209.7958	688.313	−1.42	F.
				Rev	−0.5480	+1.90						F.
				Mean	−0.54610							
2.590	T. B. M. 118	117 T. B. M.	156.78	Dir	−1.1214	−2.60	1.7	8.6	208.6716	684.624	−1.55	F.
				Rev	−1.1266	+2.60						F.
				Mean	−1.12400							
*0.040	P. B. M. 155	118 T. B. M.		Dir	−2.1206	+0.05	0.0	8.6	206.5508	677.666	−1.80	F.
				Rev	−2.1205	−0.05						F.
				Mean	−2.12055							
*0.040	P. B. M. 156	118 T. B. M.		Dir	−0.9027	−0.25	0.2	8.6	207.7686	681.662	−1.65	F.
				Rev	−0.9032	+0.25						F.
				Mean	−0.90295							
1.257	T. B. M. 119 and 119*a*	118 T. B. M.	158.04	Dir	+5.1394	−1.45	1.0	8.7	213.8102	701.483	−0.94	J.
				Rev	+5.1365	+1.45						J.
				Mean	+5.13795							
1.644	T. B. M. 120	119 and *a* T. B. M.	159.68	Dir	−5.1582	+0.60	0.4	8.7	208.6520	684.560	−1.55	J.
				Rev	−5.1570	−0.60						J.
				Mean	−5.1576							
0.926	T. B. M. 121	120 T. B. M.	160.61	Dir	−1.1737	−0.15	0.1	8.7	207.4780	680.708	−1.69	J.
				Rev	−1.1740	+0.15						J.
				Mean	−1.17385							
*0.024	P. B. M. 157	121 T. B. M.		Dir	−1.6885	+0.15	0.1	8.7	205.7895	675.168	−1.89	J.
				Rev	−1.6882	−0.15						J.
				Mean	−1.68835							
*0.024	P. B. M. 158	121 T. B. M.		Dir	−0.4690	+0.35	0.2	8.7	207.0093	679.170	−1.75	J.
				Rev	−0.4683	−0.35						J.
				Mean	−0.46865							
1.958	T. B. M. 122	121 T. B. M.	162.57	Dir	+1.7103	−0.55	0.4	8.7	209.1880	686.318	−1.49	F.
				Rev	+1.7092	+0.55						F.
				Mean	+1.70975							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used=3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	v	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.012	Old B. M. "1"	122 T. B. M.	163.58	Dir	−2.1514	+0.05	0.0	8.7	207.0364	679.259	−1.74	F.
				Rev	−2.1513	−0.05						F.
				Mean	−2.15135							
*0.074	Old B. M. "a"	"1" B. M		Dir	+4.0232	−0.10	0.1	8.7	211.0599	692.460	−1.26	F.
				Rev	+4.0230	+0.10						F.
				Mean	+4.02310							
*0.068	P. B. M. 159	"a" B. M.		Dir	+0.9485	+0.10	0.1	8.7	212.0086	695.573	−1.16	F.
				Rev	+0.9487	−0.10						F.
				Mean	+0.94860							
1.336	Old B. M. XXI	"1" B. M.	164.92	1. Dir	−1.3846	+2.83	1.0	8.7	205.6544	674.725	−1.90	F.
				Rev	−1.3798	−1.97						F.
				2. Dir	−1.3809	−0.87						F.
				Mean	−1.38177							
1.302	T. B. M. 123	XXI B. M.	166.28	Dir	+2.9814	+1.65	1.1	8.8	208.6378	684.513	−1.55	F.
				Rev	+2.9847	−1.65						F.
				Mean	+2.98305							
*0.017	P. B. M. 160	123 T. B. M.		Dir	+1.4711	+0.05	0.0	8.8	210.1092	689.341	−1.38	J.
				Rev	+1.4712	−0.05						J.
				Mean	+1.47115							
*0.017	P. B. M. 161	123 T. B. M.		Dir	+2.6900	−0.05	0.0	8.8	211.3281	693.340	−1.23	J.
				Rev	+2.6899	+0.05						J.
				Mean	+2.68995							
2.121	T. B. M. 124	123 T. B. M.	168.40	Dir	+0.9632	−1.45	1.0	8.9	209.5907	687.669	−1.44	J.
				Rev	+0.9603	+1.45						J.
				Mean	+0.96175							

1.632	T. B. M. 125	124 T. B. M.	170.03	Dir	−1.5205	+0.70	0.5	8.9	208.0797	682.682	−1.62	J.
				Rev	−1.5191	−0.70						J.
				Mean	−1.51980							
*0.157	P. B. M. 162	125 T. B. M.		Dir	−0.6833	−0.10	0.1	8.9	207.3962	680.440	−1.70	J.
				Rev	−0.6835	+0.10						J.
				Mean	−0.68340							
*0.157	P. B. M. 163	125 T. B. M.		Dir	+0.5340	+0.15	0.1	8.9	208.1139	684.435	−1.55	J.
				Rev	+0.5343	−0.15						J.
				Mean	+0.53415							
1.340	T. B. M. 126	125 T. B. M.	171.87	Dir	+0.8241	+1.20	0.8	8.9	208.9051	685.390	−1.52	J.
				Rev	+0.8265	−1.20						J.
				Mean	+0.82530							
1.394	T. B. M. 127	126 T. B. M.	172.76	Dir	+1.0344	+0.05	0.0	8.9	209.9397	688.785	−1.39	J.
				Rev	+1.0345	−0.05						J.
				Mean	+1.03445							
1.920	Old B. M. XVII	127 T. B. M	174.68	Dir	−2.9705	0.00	0.0	8.9	206.9688	679.038	−1.75	J.
				Rev	−2.9705	0.00						J.
				Mean	−2.97050							
0.048	P. B. M. 166	XVII B. M.	174.73	Dir	−0.2443	+0.25	0.2	8.9	206.7248	678.237	−1.77	F.
				Rev	−0.2438	−0.25						F.
				Mean	−0.24405							
*0.132	P. B. M. 164	166 P. B. M.		Dir	−3.2120	−0.25	0.2	8.9	203.5121	667.697	−2.15	F.
				Rev	−3.2125	+0.25						F.
				Mean	−3.21225							
*0.131	P. B. M. 165	166 P. B. M.		Dir	−1.9995	+0.10	0.1	8.9	204.7251	671.676	−2.01	F.
				Rev	−1.9993	−0.10						F.
				Mean	−1.99940							
0.996	P. B. M. 167	166 P. B. M.	175.73	Dir	+1.1525	−0.80	0.5	8.9	207.8766	682.016	−1.64	F.
				Rev	+1.1509	+0.80						F.
				Mean	+1.15170							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
0.190	Old B. M. on water tower	167 P. B. M	175.92	Dir	−0.8799	−0.10	0.1	8.9	206.9965	679.128	−1.75	F.
				Rev	−0.8801	+0.10						F.
				Mean	−0.88000							
*0.050	Old B. M. "b"	Old B. M		Dir	+0.0945	+0.20	0.1	8.9	207.0912	679.439	−1.74	F.
				Rev	+0.0049	−0.20						F.
				Mean	+0.09470							
*0.159	U. S. gauge, zero of "Winona"	"b" B. M		Dir	−5.8334	+0.45	0.3	8.9	201.2576	660.300	−2.43	F.
				Rev	−5.8325	−0.45						F.
				Mean	−5.83295							
*0.071	New gauge zero of	Old gauge		Dir	+0.0126	−0.65	0.4	8.9	201.2695	660.339	−2.43	F.
				Rev	+0.0113	+0.65						F.
				Mean	+0.01195							
*0.020	City B. M	Old B. M		Dir	−0.2306	0.00	0.0	8.9	206.7659	678.372	−1.77	F.
				Rev	−0.2306	0.00						F.
				Mean	−0.23060							
0.357	P. B. M 168	Old B. M		Dir	+2.2653	−0.50	0.3	8.9	209.2616	686.560	−1.48	J.
				Rev	+2.2643	+0.50						J.
				Mean	+2.26480							
0.680	Old B. M. "B"	Old B. M	176.60	Dir	−0.3651	−0.20	0.1	8.9	206.6312	677.930	−1.78	F.
				Rev	−0.3655	+0.20						F.
				Mean	−0.36530							
0.318	Old B. M. on Liberty and Second streets	"B" B. M	176.92	Dir	+1.0287	+0.55	0.4	8.9	207.6605	681.307	−1.67	F.
				Rev	+1.0298	−0.55						F.
				Mean	+1.02925							

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1.800	Old B. M. on Keyes barn	B. M	178.72	Dir	+2.0210	+2.00	1.3	9.1	209.6838	687.945	—1.43	F.
				Rev	+2.0250	—2.00						F.
				Mean	+2.02300							
*0.170	P. B. M. 169	B. M. Keyes		Dir	—1.1780	+0.50	0.3	9.1	208.5111	684.098	—1.57	F.
				Rev	—1.1720	—0.50						F.
				Mean	—1.17250							
0.755	T. B. M. 128	B. M. Keyes	179.47	Dir	—6.6833	—0.85	0.6	9.1	202.9968	666.013	—2.23	F.
				Rev	—6.6850	+0.85						F.
				Mean	—6.68415							
2.668	T. B. M. 129	128 T. B. M	182.14	Dir	+2.4579	+0.35	0.2	9.1	205.4574	674.079	—1.93	F.
				Rev	+2.4586	—0.35						F.
				Mean	+2.45825							
*0.018	P. B. M. 170	129 T. B. M		Dir	—1.0882	+0.25	0.2	9.1	204.3693	670.509	—2.06	J.
				Rev	—1.0877	—0.25						J.
				Mean	—1.08795							
*0.018	P. B. M. 171	129 T. B. M		Dir	+0.1289	—0.15	0.1	9.1	205.5861	674.501	—1.92	J.
				Rev	+0.1286	+0.15						J.
				Mean	+0.12875							
0.936	T. B. M. 130	129 T. B. M	183.08	Dir	+0.6443	+0.25	0.2	9.1	206.1020	676.194	—1.86	J.
				Rev	+0.6448	—0.25						J.
				Mean	+0.64455							
1.864	T. B. M. 131	130 T. B. M	184.94	Dir	+1.3624	+0.65	0.4	9.1	207.4652	680.666	—1.69	J.
				Rev	+1.3637	—0.65						J.
				Mean	+1.36305							
*0.112	P. B. M. 172	131 T. B. M		Dir	—0.7437	+0.30	0.2	9.1	206.7217	678.227	—1.77	J.
				Rev	—0.7431	—0.30						J.
				Mean	—0.74340							
*0.112	P. B. M. 173	131 T. B. M		Dir	+0.4727	+0.30	0.2	9.1	207.9382	682.218	—1.63	J.
				Rev	+0.4733	—0.30						J.
				Mean	+0.47300							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used =3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.704	T. B. M. 132	131 T. B. M	186.64	Dir	−0.7100	+0.70	0.5	9.1	206.7558	678.339	−1.77	J.
				Rev	−0.7086	−0.70						J.
				Mean	−0.70930							
1.002	T. B. M. 133	132 T. B. M	187.65	Dir	+0.7153	+1.10	0.7	9.1	207.4723	680.690	−1.69	J.
				Rev	+0.7175	−1.10						
				Mean	+0.71640							
*0.046	P. B. M. 174	133 T. B. M		Dir	+2.5708	+0.35	0.2	9.1	210.0438	689.126	1.38	J.
				Rev	+2.5715	−0.35						
				Mean	+2.57115							
*0.043	P. B. M. 175	133 T. B. M		1. Dir	+3.7913	−0.50	0.2	9.1	211.2635	693.128	−1.24	J.
				1. Rev	+3.7905	+0.30						J.
				2. Dir	+3.7903	+0.50						J.
				2. Rev	+3.7911	−0.30						J.
				Mean	+3.79080							
0.806	T. B. M. 134	133 T. B. M	188.45	1. Dir	−0.7768	−1.87	0.8	9.2	206.6935	678.134	−1.78	J.
				1. Rev	−0.7810	+2.33						J.
				2. Dir	−0.7765	−2.17						J.
				2. Rev	−0.7804	+1.73						J.
				Mean	−0.77867							
1.572	T. B. M. 135	134 T. B. M	190.02	Dir	−0.4724	+0.85	0.6	9.2	206.2219	676.587	−1.83	J.
				Rev	−0.4707	−0.85						J.
				Mean	−0.47155							
0.733	T. B. M. 136	135 T. B. M	190.76	1. Dir	−0.3985	−1.47	0.5	9.2	205.8219	675.275	−1.88	F.
				1 Rev	−0.4019	+1.93						F.
				2. Dir	−0.3992	−0.77						F.
				2. Rev	−0.4003	+0.33						F.
				Mean	−0.39997							

0.737	T. B. M. 137	136 T. B. M.	191.49	Dir	+0.4735	−1.15	0.8	9.2	206.2943	676.825	−1.83	F.
				Rev	+0.4712	+1.15						F.
				Mean	+0.47235							
*0.164	P. B. M. 176	137 T. B. M.		Dir	−0.7348	+0.90	0.6	9.2	205.5603	674.416	1.92	F.
				Rev	−0.7330	−0.90						F.
				Mean	−0.73390							
*0.164	P. B. M. 177	137 T. B. M.		Dir	+0.4308	+0.50	0.3	9.2	206.7757	678.404	−1.77	F.
				Rev	+0.4818	−0.50						F.
				Mean	+0.48130							
0.810	T. B. M. 138 and 138a	137 T. B. M.	192.30	Dir	−1.2430	+0.40	0.3	9.2	205.0516	672.748	1.98	F.
				Rev	−1.2422	−0.40						F.
				Mean	−1.24260							
*0.082	Old B. M. "120"	138-a T. B. M.		Dir	−1.1542	+0.30	0.2	9.2	203.8975	668.961	−2.12	F.
				Rev	−1.1536	−0.30						F.
				Mean	−1.15390							
0.690	T. B. M. 130	138-a T. B. M.	192.99	Dir	+0.3898	−1.00	0.7	9.3	205.4404	674.023	−1.93	F.
				Rev	+0.3878	+1.00						F.
				Mean	+0.38880							
1.242	T. B. M. 140	139 T. B. M.	194.24	Dir	+0.2766	−0.65	0.4	9.3	205.7164	674.929	−1.89	F.
				Rev	+0.2753	+0.65						F.
				Mean	+0.27595							
1.376	T. B. M. 141	140 T. B. M.	195.61	Dir	+2.6976	+0.55	0.4	9.3	208.4149	683.782	−1.57	F.
				Rev	+2.6987	−0.55						F.
				Mean	+2.69815							
0.937	T. B. M. 142	141 T. B. M.	196.55	Dir	+1.9683	−0.95	0.6	9.3	210.3824	690.237	−1.34	F.
				Rev	+1.9664	+0.95						F.
				Mean	+1.96735							
1.545	T. B. M. 143	142 T. B. M.	198.10	Dir	−4.2381	−1.30	0.9	9.3	206.1426	676.327	−1.84	F.
				Rev	−4.2407	+1.30						F.
				Mean	−4.23940							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
*0.035	P. B. M. 178	143 T. B. M.		Dir	− 0.1763	+0.15	0.1	9.3	205.9664	675.749	−1.87	F.
				Rev	− 0.1760	−0.15						F.
				Mean	− 0.17615							
*0.035	P. B. M. 179	143 T. B. M.		Dir	+ 1.0438	−0.30	0.2	9.3	207.1862	679.751	−1.73	F.
				Rev	+ 1.0432	+0.30						F.
				Mean	+ 1.04350							
0.422	T. B. M. 144	143 T. B. M.	198.52	1. Dir	− 0.1022	−1.13	0.7	9.4	206.0392	675.988	−1.86	F.
				1. Rev	− 0.1055	+2.17						F.
				2. Rev	− 0.1023	−1.03						
				Mean	− 0.10333							
1.910	T. B. M. 145	144 T. B. M.	200.43	1. Dir	+ 4.3279	+2.97	1.2	9.5	210.3706	690.198	−1.34	F.
				1. Rev	+ 4.3341	−3.23						F.
				2. Dir	+ 4.3306	+0.27						
				Mean	+ 4.33087							
0.838	T. B. M. 146	145 T. B. M.	201.26	Dir	+ 0.3726	−1.55	1.0	9.5	210.7417	691.416	−1.30	J.
				Rev	+ 0.3695	+1.55						J.
				Mean	+ 0.37105							
*0.118	P. B. M. 180	146 T. B. M.		Dir	− 2.5219	+0.25	0.2	9.5	208.2197	683.142	1.60	F.
				Rev	− 2.5214	−0.25						F.
				Mean	− 2.52165							
*0.118	P. B. M. 181	146 T. B. M.		Dir	− 1.3002	+0.30	0.2	9.5	209.4416	687.151	−1.45	F.
				Rev	− 1.2996	−0.30						F.
				Mean	− 1.29990							
0.844	T. B. M. 147	146 T. B. M.	202.11	Dir	− 2.8550	−1.40	0.9	9.5	207.8849	682.043	−1.64	J.
				Rev	− 2.8578	+1.40						J.
				Mean	− 2.85640							

0.986	T. B. M. 148	147 T. B. M	203.09	Dir	+ 1.9780	—1.35	0.0	9.6	209.8618	688.529	—1.40	J.
				Rev	+ 1.9753	+1.35						J.
				Mean	+ 1.97665							
1.190	T. B. M. 149 and 149a	148 T. B. M	204.28	Dir	— 3.0542	—0.80	0.5	9.6	206.8065	678.505	—1.77	J.
				Rev	— 3.0558	+0.80						J.
				Mean	— 3.05500							
1.236	Old B. M. 131	149a T. B. M	205.52	Dir	— 1.6947	—0.30	0.2	9.6	205.1113	672.943	—1.96	J.
				Rev	— 1.6953	+0.30						J.
				Mean	— 1.69500							
*0.363	P. B. M. 182	131 B. M		Dir	+ 3.0600	—0.10	0.1	9.6	208.1715	682.983	—1.61	J.
				Rev	+ 3.0598	+0.10						J.
				Mean	+ 3.05990							
*0.363	P. B. M. 183	131 B. M		Dir	+ 4.2783	+0.40	0.3	9.6	209.3905	686.983	—1.46	J.
				Rev	+ 4.2791	—0.40						J.
				Mean	+ 4.27870							
1.697	T. B. M. 150	131 B. M	207.22	Dir	+ 8.6588	—0.50	0.3	9.6	213.7706	701.353	—0.94	F.
				Rev	+ 8.6578	+0.50						F.
				Mean	+ 8.65830							
0.765	P. B. M. 184	150 T. B. M	207.98	Dir	+ 2.5796	+0.55	0.4	9.6	216.3510	709.819	—0.63	F.
				Rev	+ 2.5807	—0.55						F.
				Mean	+ 2.58015							
*0.322	Old B. M. 130½; also called Old P. B. M. 18	184 P. B. M		Dir	—12.6157	+0.20	0.1	9.6	203.7340	668.425	—2.13	F.
				Rev	—12.6153	—0.20						F.
				Mean	—12.61550							
1.210	T. B. M. 151	184 P. B. M	209.19	1. Dir	— 9.0707	—2.25	1.1	9.7	207.2770	680.049	—1.71	F.
				1. Rev	— 9.0777	+4.75						F.
				2. Dir	— 9.0726	—0.35						F.
				2. Rev	— 9.0708	—2.15						F.
				Mean	— 9.07295							
*0.022	P. B. M. 185	151 T. B. M		Dir	— 1.0864	—0.05	0.0	9.7	206.1904	676.484	—1.84	F.
				Rev	— 1.0865	+0.05						F.
				Mean	— 1.08645							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

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Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V.	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
*0.022	P. B. M. 186	151 T. B. M		Dir	+ 0.1355	+0.05	0.0	9.7	207.4126	680.494	—1.69	F.
				Rev	+ 0.1356	—0.05						F.
				Mean	+ 0.13555							
1.005	T. B. M. 152	151 T. B. M	210.20	Dir	+ 2.2602	+1.55	1.0	9.7	209.5390	687.470	—1.44	J.
				Rev	+ 2.2633	—1.55						J.
				Mean	+ 2.26175							
1.110	T. B. M. 153	152 T. B. M	211.31	Dir	— 1.2122	+2.00	1.3	9.8	208.3287	683.499	—1.58	J.
				Rev	— 1.2082	—2.00						J.
				Mean	— 1.21020							
1.832	T. B. M. 154	153 T. B. M	213.14	Dir	— 0.9193	+0.70	0.5	9.8	207.4100	680.485	—1.70	J.
				Rev	— 0.9179	—0.70						J.
				Mean	— 0.91860							
1.460	T. B. M. 155	154 T. B. M	214.60	Dir	— 4.9825	—1.00	0.6	9.8	202.4259	664.133	—2.28	F.
				Rev	— 4.9845	+1.00						F.
				Mean	— 4.98350							
*0.233	P. B. M. 187	155 T. B. M		Dir	+ 2.6869	+0.25	0.2	9.8	205.1134	672.950	—1.96	F.
				Rev	+ 2.6874	—0.25						F.
				Mean	+ 2.68715							
*0.233	P. B. M. 188	155 T. B. M		Dir	+ 3.9116	+0.30	0.2	9.8	206.3383	676.969	—1.82	F.
				Rev	+ 3.9122	—0.30						F.
				Mean	+ 3.91190							
1.136	T. B. M. 156	155 T. B. M	215.73	Dir	+ 0.9723	+1.75	1.2	9.8	203.4000	667.329	—2.18	F.
				Rev	+ 0.9758	—1.75						F.
				Mean	+ 0.97405							
1.165	Old B. M. 139, also called old P. B. M. 19	156 T. B. M	216.90	Dir	+ 1.3249	+1.55	1.0	9.9	204.7267	671.682	—2.01	F.

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				Rev	+ 1.3280	—1.55						F.
				Mean	+ 1.32645							
*0.020	P. B. M. 189	139 B. M		Dir	+ 0.5078	0.00	0.0	9.9	205.2345	673.348	—1.95	F.
				Rev	+ 0.5078	0.00						F.
				Mean	+ 0.50780							
*0.220	U. S. gauge zero of (La Crosse)	139 B. M		Dir	— 7.00056			9.9	197.7253	648.711	—2.84	F.
				Mean	— 7.00056							
0.733	P. B. M. 190	139 B. M	217.64	Dir	+ 0.5301	+0.75	0.5	9.9	205.2576	673.423	—1.95	F.
				Rev	+ 0.5316	—0.75						F.
				Mean	+ 0.53085							
1.254	T. B. M. 157	190 P. B. M	218.89	1. Dir	— 1.1875	—3.12	0.9	10.0	204.0668	669.516	—2.10	J.
				1. Rev	— 1.1939	+3.28						J.
				2. Dir	— 1.1899	—0.72						J.
				2. Rev	— 1.1912	+0.58						J.
				Mean	— 1.19062							
*0.094	P. B. M. 191	157 T. B. M		Dir	— 0.7139	0.00	0.0	10.0	203.3528	667.174	—2.18	J.
				Rev	— 0.7139	0.00						J.
				Mean	— 0.71390							
0.642	T. B. M. 158	157 T. B. M	219.53	Dir	— 1.0516	+0.90	0.6	10.0	203.0160	666.069	—2.21	J.
				Rev	— 1.0498	—0.90						J.
				Mean	— 1.05070							
1.355	T. B. M. 159	158 T. B. M	220.89	Dir	— 2.5645	+0.10	0.1	10.0	200.4513	657.0655	—2.52	J.
				Rev	— 2.5643	—0.10						J.
				Mean	— 2.56440							
0.780	City B. M. Front street (La Crosse)	159 T. B. M	221.67	Dir	+ 4.2658	+0.30	0.2	10.0	204.7179	671.653	—2.01	J.
				Rev	+ 4.2664	—0.30						J.
				Mean	+ 4.2661							
*	La Crosse City Datum	B. M. Front street			—15.23984			10.0	189.4781	621.653	—2.01	
*0.515	P. B. M. 192	B. M. Front street		Dir	+ 8.5815	—0.80	0.5	10.0	213.2996	699.808	—1.00	F.
				Rev	+ 8.5799	+0.80						F.
				Mean	+ 8.58070							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
0.288	T. B. M. 160	B. M. Front street.	221.96	Dir	+1.8582	+ 0.40	0.3	10.0	206.5767	677.751	—1.80	F.
				Rev	+1.8500	— 0.40						F.
				Mean	+1.85860							
*0.250	City B. M. at end of bridge 39.51 above City Datum.	160 T. B. M		Dir	—5.0436	— 0.40	0.3	10.0	201.5321	661.200	—2.39	F.
				Rev	—5.0444	+ 0.40						F.
				Mean	—5.04400							
*0.022	P. B. M. 193	B. M. city		Dir	+0.9057	0.00	0.0	10.0	202.4379	664.172	—2.28	F.
				Rev	+0.9057	0.00						F.
				Mean	+0.90570							
0.009	U. S. S. S. gauge, zero of (La Crosse)	B. M. city		Dir	—4.8234	— 0.25	0.2	10.0	196.7079	645.373	—2.98	J.
				Rev	—4.8239	+ 0.25						J.
				Mean	—4.82365							
0.880	T. B. M. 161	160 T. B. M.	222.84	Dir	+0.8767	+ 0.05	0.0	10.0	207.4536	680.628	—1.60	F.
				Rev	+0.8768	— 0.05						F.
				Mean	+0.87675							
1.602	T. B. M. 162	161 T. B. M.	224.44	Dir	+4.2063	+ 1.85	1.2	10.0	211.6585	694.424	—1.19	F.
				Rev	+4.2026	— 1.85						F.
				Mean	+4.20445							
2.204	T. B. M. 163	162 T. B. M.	226.64	Dir	—4.5072	— 0.05	0.0	10.1	207.1507	679.634	—1.73	F.
				Rev	—4.5073	+ 0.05						F.
				Mean	—4.50725							
1.444	T. B. M. 164	163 T. B. M.	228.09	1. Dir	—2.6058	+ 3.43	1.1	10.2	204.5480	671.095	—2.64	J.
				" Rev	—2.6205†	+18.13						J.
				2. Dir	—2.6006	— 1.77						J.
				" Rev	—2.6007	— 1.07						J.
				Mean	—2.60237							

*0.112	P. B. M. 194	164 T. B. M.		Dir	−0.3800	0.00	0.0	10.2	204.1680	669.849	−2.08	J.
				Rev	−0.3800	0.00						J.
				Mean	−0.38000							
*0.112	P. B. M. 195	164 T. B. M.		Dir	+0.8379	− 0.35	0.2	10.2	205.3857	673.844	−1.94	J.
				Rev	+0.8372	+ 0.35						J.
				Mean	+0.83755							
1.120	T. B. M. 165 and 165*a*	164 T. B. M.	229.21	1. Dir	−1.1491	+ 0.23	0.1	10.2	203.3990	667.326	−2.18	J.
				" Rev	−1.1395†	− 9.37						J.
				2. Dir	−1.1482	− 0.67						J.
				" Rev	−1.1493	+ 0.43						J.
				Mean	−1.14887							
2.004	T. B. M. 166 and 166*a*	165 and *a* T. B. M.	231.21	Dir	−0.3478	+ 0.90	0.6	10.2	203.0521	666.187	−2.21	F.
				Rev	−0.3460	− 0.90						F.
				Mean	−0.34690							
2.057	T. B. M. 167 and 167*a*	166 and *a* T. B. M.	233.27	Dir	−1.4508	− 0.25	0.2	10.2	201.5919	661.397	−2.39	F.
				Rev	−1.4603	+ 0.25						F.
				Mean	−1.46005							
1.836	T. B. M. 168	167 and *a* T. B. M.	234.60	Dir	+0.0871	− 0.05	0.0	10.2	201.6789	661.082	−2.38	F.
				Rev	+0.0870	+ 0.05						F.
				Mean	+0.08705							
*0.026	P. B. M. 196	168 T. B. M.		Dir	+0.5567	+ 0.10	0.1	10.2	202.2358	663.509	−2.31	F.
				Rev	+0.5569	− 0.10						F.
				Mean	+0.55680							
*0.026	P. B. M. 197	168 T. B. M.		Dir	+1.7701	+ 0.15		10.2	203.4494	667.491	−2.17	F.
				Rev	+1.7704	− 0.15	0.1					F.
				Mean	+1.77025							
1.780	T. B. M. 169 and 169*a*	168 T. B. M.	236.38	Dir	−0.1376	− 1.40	0.9	10.2	201.5399	661.226	−2.39	J.
				Rev	−0.1404	+ 1.40						J.
				Mean	−0.13900							

† Rejected.

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May [illegible], 18[illegible], to October [illegible], 18[illegible]—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used [illegible] feet.]

B. B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	[illegible]	[illegible]	[illegible]	Elevation above Cairo datum.		Red vol.	[illegible]
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
2.284	T. B. M. 181 and 181*a*	180 T. B. M.	254.87	Dir	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				Rev	[illegible]	[illegible]						
				Mean	[illegible]							
1.099	T. B. M. 182	181 and 181*a* T. B. M.	[illegible]	Dir	+0.4[illegible]	±1.45	1.0	10.7	[illegible]	[illegible]	[illegible]	[illegible]
				Rev	+0.4[illegible]	1.45						
				Mean	+0.4[illegible]							
*0.024	P. B. M. 204	182 T. B. M.		Dir	[illegible]	±0.[illegible]	0.1	10.7	[illegible]	[illegible]	[illegible]	[illegible]
				Rev	[illegible]	0.[illegible]						
				Mean	[illegible]							
*0.024	P. B. M. 205	182 T. B. M.		Dir	[illegible]	0.00	0.0	10.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				Rev	[illegible]	0.00						
				Mean	[illegible]							
0.524	T. B. M. 183	182 T. B. M.	[illegible]	Dir	[illegible]	[illegible]	0.4	10.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				Rev	[illegible]	[illegible]						
				Mean	[illegible]							
0.976	T. B. M. 184	183 T. B. M.	[illegible]	Dir	+1.[illegible]	±0.00			[illegible]	[illegible]	[illegible]	[illegible]
				Rev	+1.[illegible]	0.00	0.4	10.7				
				Mean	+1.20100							
1.115	T. B. M. 185	184 T. B. M.	258.58	Dir	+0.87[illegible]	±1.05	0.7	10.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				Rev	+0.8807	1.05						
				Mean	+0.87065							
1.888	T. B. M. 186	185 T. B. M.	259.97	Dir	+0.10[illegible]	±0.15	0.1	10.7	301.5[illegible]	[illegible]	[illegible]	[illegible]
				Rev	+0.1035	0.15						
				Mean	+0.10835							

*0.058	P. B. M. 206	186 T. B. M.		Dir	+0.5057	−0.10	0.1	10.7	202.0378	662.860	−2.33	J.
				Rev	+0.5055	+0.10						J.
				Mean	+0.50560							
*0.058	P. B. M. 207	186 T. B. M.		Dir	+1.7280	−0.25	0.2	10.7	203.2601	666.870	−2.19	J.
				Rev	+1.7275	+0.25						J.
				Mean	+1.72775							
1.641	T. B. M. 187	186 T. B. M.	261.61	Dir	−1.8405	−1.15	0.8	10.8	199.6903	655.158	−2.62	F.
				Rev	−1.8428	+1.15						F.
				Mean	−1.84165							
*0.018	P. B. M. 208	187 T. B. M.		Dir	+1.6458	+0.20	0.1	10.8	201.3365	660.559	−2.42	F.
				Rev	+1.6462	−0.20						F.
				Mean	+1.64600							
1.685	T. B. M. 188	187 T. B. M.	263.30	Dir	+1.0459	+0.15	0.1	10.8	200.7365	658.590	−2.49	F.
				Rev	+1.0462	−0.15						F.
				Mean	+1.04605							
0.838	T. B. M. 189	188 T. B. M.	264.13	Dir	−0.9220	−0.15	0.1	10.8	199.8142	655.564	−2.60	J.
				Rev	−0.9223	+0.15						J.
				Mean	−0.92215							
0.726	T. B. M. 190	189 T. B. M.	264.86	Dir	−0.5294	−0.75	0.5	10.8	199.2840	653.825	−2.67	J.
				Rev	−0.5309	+0.75						J.
				Mean	−0.53075							
*0.089	P. B. M. 209	190 T. B. M.		Dir	−0.1149	−0.20	0.1	10.8	199.1689	653.447	−2.68	J.
				Rev	−0.1153	+0.20						J.
				Mean	−0.11510							
*0.089	P. B. M. 210	190 T. B. M.		Dir	+1.1067	−0.35	0.2	10.8	200.3905	657.455	−2.54	J.
				Rev	+1.1060	+0.35						J.
				Mean	+1.10635							
0.858	T. B. M. 191	190 T. B. M.	265.72	Dir	+1.1976	−0.40	0.3	10.8	200.4814	657.753	−2.52	J.
				Rev	+1.1968	+0.40						J.
				Mean	+1.19720							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	v	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
0. 288	T. B. M. 160	B. M. Front street.	231. 96	Dir	+1. 8582	+ 0. 40	0. 3	10. 0	206. 5767	677. 751	−1. 80	F.
				Rev	+1. 8590	− 0. 40						F.
				Mean	+1. 85860							
*0. 250	City B. M. at end of bridge 39.51 above City Datum.	160 T. B. M		Dir	−5. 0436	− 0. 40	0. 3	10. 0	201. 5321	661. 200	−2. 39	F.
				Rev	−5. 0444	+ 0. 40						F.
				Mean	−5. 04400							
*0. 022	P. B. M. 193	B. M. city		Dir	+0. 9057	0. 00	0. 0	10. 0	202. 4379	664. 172	−2. 28	F.
				Rev	+0. 9057	0. 00						F.
				Mean	+0. 90570							
0. 009	U. S. S. S. gauge, zero of (La Crosse)	B. M. city		Dir	−4. 8234	− 0. 25	0. 2	10. 0	190. 7079	645. 373	−2. 98	J.
				Rev	−4. 8239	+ 0. 25						J.
				Mean	−4. 82365							
0. 880	T. B. M. 161	160 T. B. M	222. 84	Dir	+0. 8767	+ 0. 05	0. 0	10. 0	207. 4536	680. 628	−1. 69	F.
				Rev	+0. 8768	− 0. 05						F.
				Mean	+0. 87675							
1. 602	T. B. M. 162	161 T. B. M	224. 44	Dir	+4. 2063	+ 1. 85	1. 2	10. 0	211. 6585	694. 424	−1. 19	F.
				Rev	+4. 2026	− 1. 85						F.
				Mean	+4. 20445							
2. 204	T. B. M. 163	162 T. B. M	226. 64	Dir	−4. 5072	− 0. 05	0. 0	10. 1	207. 1507	679. 634	−1. 73	F.
				Rev	−4. 5073	+ 0. 05						F.
				Mean	−4. 50725							
1. 444	T. B. M. 164	163 T. B. M	228. 09	1. Dir	−2. 6058	+ 3. 43	1. 1	10. 2	204. 5480	671. 095	−2. 64	J.
				" Rev	−2. 6205	+18. 13						J.
				2. Dir	−2. 6006	− 1. 77						J.
				" Rev	−2. 6007	− 1. 07						J.
				Mean	−2. 60237							

*0.112	P. B. M. 194	164 T. B. M.		Dir	−0.3800	0.00	0.0	10.2	204.1680	669.849	−2.08	J.
				Rev	−0.3800	0.00						J.
				Mean	−0.38000							
*0.112	P. B. M. 195	164 T. B. M.		Dir	+0.8379	− 0.35	0.2	10.2	205.3857	673.844	−1.94	J.
				Rev	+0.8372	+ 0.35						J.
				Mean	+0.83755							
1.120	T. B. M. 165 and 165*a*	164 T. B. M.	229.21	1. Dir	−1.1491	+ 0.23	0.1	10.2	203.3990	667.326	−2.18	J.
				" Rev	−1.1395†	− 9.37						J.
				2. Dir	−1.1482	− 0.67						J.
				" Rev	−1.1493	+ 0.43						J.
				Mean	−1.14887							
2.004	T. B. M. 166 and 166*a*	165 and *a* T. B. M.	231.21	Dir	−0.3478	+ 0.90	0.6	10.2	203.0521	666.187	−2.21	F.
				Rev	−0.3460	− 0.90						F.
				Mean	−0.34690							
2.057	T. B. M. 167 and 167*a*	166 and *a* T. B. M.	238.27	Dir	−1.4598	− 0.25	0.2	10.2	201.5919	661.397	−2.39	F.
				Rev	−1.4603	+ 0.25						F.
				Mean	−1.46005							
1.836	T. B. M. 168	167 and *a* T. B. M.	234.60	Dir	+0.0871	− 0.05	0.0	10.2	201.6789	661.082	−2.38	F.
				Rev	+0.0870	+ 0.05						F.
				Mean	+0.08705							
*0.026	P. B. M. 196	168 T. B. M.		Dir	+0.5567	+ 0.10	0.1	10.2	202.2358	663.509	−2.31	F.
				Rev	+0.5569	− 0.10						F.
				Mean	+0.55680							
*0.026	P. B. M. 197	168 T. B. M.		Dir	+1.7701	+ 0.15		10.2	203.4494	667.491	−2.17	F.
				Rev	+1.7704	− 0.15	0.1					F.
				Mean	+1.77025							
1.780	T. B. M. 169 and 169*a*	168 T. B. M.	236.38	Dir	−0.1376	− 1.40	0.9	10.2	201.5399	661.226	−2.39	J.
				Rev	−0.1404	+ 1.40						J.
				Mean	−0.13900							

† Rejected.

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Red cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
0.992	T. B. M. 170	169 and a T. B. M	237.38	Dir	+0.5802	+0.75	0.5	10.2	202.1210	663.133	−2.32	J.
				Rev	+0.5817	−0.75						J.
				Mean	+0.58095							
1.230	T. B. M. 171 and 171a	170 T. B. M	238.61	Dir	−0.6249	−1.00	0.7	10.2	201.4950	661.079	−2.40	F.
				Rev	−0.6269	+1.00						F.
				Mean	−0.62590							
1.357	T. B. M. 172	171 and a T. B. M	239.96	Dir	+0.0464	+1.85	1.2	10.3	201.5432	661.237	−2.39	F.
				Rev	+0.0501	−1.85						F.
				Mean	+0.04825							
0.985	P. B. M. 198	172 T. B. M	240.95	Dir	+1.3778	−0.85	0.6	10.3	202.9203	665.755	−2.23	F.
				Rev	+1.3761	+0.85						F.
				Mean	+1.37695							
1.742	T. B. M. 173	198 P. B. M	242.69	Dir	−1.6727	+2.30	1.5	10.5	201.2497	660.274	−2.43	F.
				Rev	−1.6681	−2.30						F.
				Mean	−1.67040							
1.827	T. B. M. 174	173 T. B. M	244.52	Dir	−0.6489	−0.45	0.3	10.5	200.6003	658.143	−2.51	F.
				Rev	−0.6498	+0.45						F.
				Mean	−0.64935							
*0.084	P. B. M. 199	174 T. B. M		Dir	−0.3503	+0.45	0.3	10.5	200.2504	656.995	−2.55	J.
				Rev	−0.3494	−0.45						J.
				Mean	−0.34985							
*0.084	P. B. M. 200	174 T. B. M		Dir	+0.8687	−0.10	0.1	10.5	201.4690	660.993	−2.40	J.
				Rev	+0.8685	+0.10						J.
				Mean	+0.86860							

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1.625	T. B. M. 175	174 T. B. M	246.14	Dir	+1.7613	−1.65	1.1	10.5	202.3602	663.917	−2.30	J.
				Rev	+1.7580	+1.65						J.
				Mean	+1.75965							
1.698	T. B. M. 176	175 T. B. M	247.84	Dir	−0.8745	−0.65	0.4	10.5	201.4849	661.046	−2.40	J.
				Rev	−0.8758	+0.65						J.
				Mean	−0.87515							
0.698	T. B. M. 177	176 T. B. M	248.54	Dir	−0.1956	+0.05	0.0	10.5	201.2893	660.404	−2.43	J.
				Rev	−0.1955	−0.05						J.
				Mean	−0.19555							
*0.210	P. B. M. 201	177 T. B. M		Dir	−0.5664	−0.25	0.2	10.5	200.7226	658.545	−2.49	J.
				Rev	−0.5669	+0.25						J.
				Mean	−0.56665							
*0.210	P. B. M. 202	177 T. B. M		Dir	+0.6571	−0.35	0.2	10.5	201.9462	662.559	−2.34	J.
				Rev	+0.6564	+0.35						J.
				Mean	+0.65675							
1.546	T. B. M. 178	177 T. B. M.	250.08	Dir	+0.5774	−1.30	0.8	10.6	201.8655	662.294	−2.36	J.
				Rev	+0.5748	+1.30						J.
				Mean	+0.57610							
0.894	T. B. M. 179	178 T. B. M.	250.98	Dir	−1.3903	−1.00	0.7	10.6	200.4740	657.729	−2.52	J.
				Rev	−1.3923	+1.00						J.
				Mean	−1.39130							
*0.080	P. B. M. 203	179 T. B. M		Dir	+5.8634	−0.60	0.4	10.6	206.3376	676.967	−1.82	J.
				Rev	+5.8622	+0.60						J.
				Mean	+5.86280							
*0.048	Old B. M., "i," also called Old B. M. 21	179 T. B. M		Dir	+0.7504	+0.15	0.1	10.6	201.2247	660.192	−2.43	J.
				Rev	+0.7507	−0.15						J.
				Mean	+0.75055							
1.606	T. B. M. 180	179 T. B. M	252.58	Dir	+1.3031	−1.55	1.0	10.6	201.7758	662.000	−2.37	J.
				Rev	+1.3060	+1.55						J.
				Mean	+1.30.55							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r_0 ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
2.284	T. B. M. 181 and 181*a*	180 T. B. M	254.87	Dir	—1.1717	—0.15	0.1	10.6	200.6038	658.155	—2.51	F.
				Rev	—1.1720	+0.15						F.
				Mean	—1.17185							
1.099	T. B. M. 182	181 and *a* T. B. M	255.97	Dir	+0.4351	+1.45	1.0	10.7	201.0404	659.587	—2.48	F.
				Rev	+0.4380	—1.45						F.
				Mean	+0.43655							
*0.024	P. B. M. 204	182 T. B. M		Dir	—1.5177	+0.15	0.1	10.7	199.5226	654.608	—2.63	F.
				Rev	—1.5174	—0.15						F.
				Mean	—1.51755							
*0.024	P. B. M. 205	182 T. B. M		Dir	—0.2988	0.00	0.0	10.7	200.7415	658.607	—2.49	F.
				Rev	—0.2988	0.00						F.
				Mean	—0.29880							
0.524	T. B. M. 183	182 T. B. M	256.49	Dir	—1.8417	—0.55	0.4	10.7	199.1979	653.542	—2.68	F.
				Rev	—1.8428	+0.55						F.
				Mean	—1.84225							
0.976	T. B. M. 184	183 T. B. M	257.47	Dir	+1.2604	+0.60			200.4590	657.680	—2.52	F.
				Rev	+1.2616	—0.60	0.4	10.7				F.
				Mean	+1.26100							
1.115	T. B. M. 185	184 T. B. M	258.58	Dir	+0.8786	+1.05	0.7	10.7	201.3388	660.566	—2.42	J.
				Rev	+0.8807	—1.05						J.
				Mean	+0.87965							
1.388	T. B. M. 186	185 T. B. M	259.97	Dir	+0.1932	+0.15	0.1	10.7	301.5322	661.201	—2.39	J.
				Rev	+0.1935	—0.15						J.
				Mean	+0.19335							

*0.058	P. B. M. 206	186 T. B. M.		Dir	+0.5057	-0.10	0.1	10.7	202.0378	662.860	-2.33	J.
				Rev	+0.5055	+0.10						J.
				Mean	+0.50560							
*0.058	P. B. M. 207	186 T. B. M.		Dir	+1.7280	-0.25	0.2	10.7	203.2601	666.870	-2.19	J.
				Rev	+1.7275	+0.25						J.
				Mean	+1.72775							
1.641	T. B. M. 187	186 T. B. M.	261.61	Dir	-1.8405	-1.15	0.8	10.8	199.6903	655.158	-2.62	F.
				Rev	-1.8428	+1.15						F.
				Mean	-1.84165							
*0.018	P. B. M. 208	187 T. B. M.		Dir	+1.6458	+0.20	0.1	10.8	201.3365	660.559	-2.42	F.
				Rev	+1.6462	-0.20						F.
				Mean	+1.64600							
1.685	T. B. M. 188	187 T. B. M.	263.30	Dir	+1.0459	+0.15	0.1	10.8	200.7365	658.590	-2.49	F.
				Rev	+1.0462	-0.15						F.
				Mean	+1.04605							
0.838	T. B. M. 189	188 T. B. M.	264.13	Dir	-0.9220	-0.15	0.1	10.8	199.8142	655.564	-2.60	J.
				Rev	-0.9223	+0.15						J.
				Mean	-0.92215							
0.726	T. B. M. 190	189 T. B. M.	264.86	Dir	-0.5294	-0.75	0.5	10.8	199.2840	653.825	-2.67	J.
				Rev	-0.5309	+0.75						J.
				Mean	-0.53075							
*0.089	P. B. M. 209	190 T. B. M.		Dir	-0.1149	-0.20	0.1	10.8	199.1689	653.447	-2.68	J.
				Rev	-0.1153	+0.20						J.
				Mean	-0.11510							
*0.089	P. B. M. 210	190 T. B. M.		Dir	+1.1067	-0.35	0.2	10.8	200.3905	657.455	-2.54	J.
				Rev	+1.1060	+0.35						J.
				Mean	+1.10635							
0.858	T. B. M. 191	190 T. B. M.	265.72	Dir	+1.1976	-0.40	0.3	10.8	200.4814	657.753	-2.52	J.
				Rev	+1.1968	+0.40						J.
				Mean	+1.19720							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.102	T. B. M. 192	191 T. B. M	266.82	Dir	+0.1307	−2.00	1.3	10.8	200.6101	658.176	−2.51	F.
				Rev	+0.1267	+2.00						F.
				Mean	+0.12870							
1.507	T. B. M. 193	192 T. B. M	268.33	Dir	+1.2537	+1.60	1.1	10.8	201.8655	662.294	−2.36	F.
				Rev	+1.2569	−1.60						F.
				Mean	+1.25530							
*0.056	P. B. M. 211	193 T. B. M		Dir	−4.7588	−0.10	0.1	10.8	197.1060	646.679	−2.93	F.
				Rev	−4.7590	+0.10						F.
				Mean	−4.75890							
0.897	P. B. M. 212	193 T. B. M	269.22	Dir	−1.7183	−1.20	0.8	10.9	200.1458	656.652	−2.56	F.
				Rev	−1.7207	+1.20						F.
				Mean	−1.71950							
1.478	T. B. M. 194	212 P. B. M	270.70	Dir	+0.8224	−0.20	0.1	10.9	200.9681	659.350	−2.46	J.
				Rev	+0.8220	+0.20						J.
				Mean	+0.82220							
1.430	T. B. M. 195	194 T. B. M	272.13	Dir	−0.8107	−0.90	0.6	10.9	200.1564	656.687	−2.56	J.
				Rev	−0.8125	+0.90						J.
				Mean	−0.81160							
*0.016	P. B. M. 213	195 T. B. M		1. Dir	−1.4848	+0.70	0.2	10.9	198.6721	651.817	−2.74	J.
				1. Rev	−1.4840	−0.10						J.
				2. Dir	−1.4840	−0.10						J.
				2. Rev	−1.4836	−0.50						J.
				Mean	−1.48410							
*0.016	P. B. M. 214	195 T. B. M		1. Dir	−0.2746	−0.45	0.1	10.9	199.8813	655.784	−2.60	J.
				1. Rev	−0.2755	+0.45						J.
				2. Dir	−0.2751	+0.05						J.

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				2. Rev	—0.2750	—0.05						J.
				Mean	—0.27505							
1.100	T. B. M. 106	195 T. B. M	273.23	Dir	—0.2664	0.00	0.0	10.9	199.8900	655.813	—2.60	J.
				Rev	—0.2664	0.00						J.
				Mean	—0.26640							
1.224	T. B. M. 197	196 T. B. M	274.46	Dir	+0.2255	—0.30	0.2	10.9	200.1152	656.552	—2.56	F.
				Rev	+0.2249	+0.30						F.
				Mean	+0.22520							
2.492	T. B. M. 198	197 T. B. M	276.95	Dir	—0.8803	—1.15	0.8	11.0	199.2336	653.659	—2.67	F.
				Rev	—0.8826	+1.15						F.
				Mean	—0.88145							
*0.012	P. B. M. 215	198 T. B. M		Dir	—0.3902	+0.20	0.1	11.0	198.8436	652.880	—2.71	J.
				Rev	—0.3898	—0.20						J.
				Mean	—0.39000							
*0.012	P. B. M. 216	198 T. B. M		Dir	+0.8307	—0.30	0.1	11.0	200.0642	656.384	—2.57	J.
				Rev	+0.8303	+0.20						J.
				Mean	+0.8305							
1.870	T. B. M. 199	198 T. B. M	278.82	1. Dir	+1.4632	+2.05	0.9	11.0	200.6991	658.468	—2.50	J.
				1. Rev	+1.4690	—3.75						J.
				2. Dir	+1.4632	+2.05						J.
				2. Rev	+1.4656	—0.35						J.
				Mean	+1.46525							
1.388	T. B. M. 200	199 T. B. M	279.71	Dir	—1.6689	—0.90	0.6	11.0	199.0291	652.988	—2.69	J.
				Rev	—1.6707	+0.90						J.
				Mean	—1.66980							
1.188	T. B. M. 201	200 T. B. M	280.89	Dir	—0.1792	+0.05	0.0	11.0	198.8499	652.401	—2.71	F.
				Rev	—0.1791	—0.05						F.
				Mean	—0.17915							
*0.040	P. B. M. 217	201 T. B. M		Dir	—1.0400	0.00	0.0	11.0	197.8098	648.988	—2.84	F.
				Rev	—1.0400	0.00						F.
				Mean	—1.0400							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used=3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
*0.040	P. B. M. 218	201 T. B. M.		Dir	+0.1813	+0.05	0.0	11.0	199.0313	652.996	—2.69	F.
				Rev	+0.1814	—0.05						F.
				Mean	+0.18135							
2.492	T. B. M. 202	201 T. B. M	283.39	Dir	+0.9383	+1.85	1.2	11.0	199.7902	655.486	—2.16	F.
				Rev	+0.9720	—1.85						F.
				Mean	+0.94015							
1.540	T. B. M. 203	202 T. B. M	284.93	Dir	—2.4766	—1.85	1.2	11.1	197.3114	647.353	—2.89	J.
				Rev	—2.4803	+1.85						J.
				Mean	—2.47845							
2.014	T. B. M. 204	203 T. B. M	286.94	Dir	+0.7837	+0.45	0.3	11.1	198.0957	649.926	—2.81	J.
				Rev	+0.7846	—0.45						J.
				Mean	+0.78415							
*0.016	P. B. M. 219	204 T. B. M		Dir	—1.6204	+0.05	0.0	11.1	196.4751	644.609	—3.00	J.
				Rev	—1.6203	—0.05						J.
				Mean	—1.62035							
*0.016	P. B. M. 220	204 T. B. M		Dir	—0.4019	—0.20	0.1	11.1	197.6935	648.607	—2.86	J.
				Rev	—0.4023	+0.20						J.
				Mean	—0.40210							
2.302	T. B. M. 205	204 T. B. M	289.24	Dir	+1.5907	—1.25	0.8	11.2	199.6853	655.141	—2.62	F.
				Rev	+1.5882	+1.25						F.
				Mean	+1.58945							
2.150	T. B. M. 206	205 T. B. M	291.39	Dir	—0.7084	—1.60	1.1	11.2	198.9752	652.812	—2.70	F.
				Rev	—0.7116	+1.60						F.
				Mean	—0.71000							
*0.016	P. B. M. 221	206 T. B. M		Dir	—0.9238	—0.20	0.1	11.2	198.0511	649.780	—2.81	J.

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				Rev	−0.9242	+0.20						J.
				Mean	−0.92400							
*0.016	P. B. M. 222	206 T. B. M		Dir	+0.2961	−0.20	0.1	11.2	199.2712	653.783	−2.67	F.
				Rev	+0.2957	+0.20						F.
				Mean	+0.29590							
1.776	T. B. M. 207	206 T. B. M	293.16	Dir	+0.7227	+0.10	0.1	11.2	199.6981	655.183	−2.62	J.
				Rev	+0.7229	−0.10						J.
				Mean	+0.72280							
0.317	T. B. M. 208	207 T. B. M	293.48	Dir	−0.2179	+0.35	0.2	11.2	199.4805	654.469	−2.64	J.
				Rev	−0.2172	−0.35						J.
				Mean	−0.21755							
*0.051	Old B. M. on N.E. corner Bright's warehouse.	208 T. B. M		Dir	+1.0687	−0.10	0.1	11.2	200.5493	657.976	−2.51	J.
				Rev	+1.0685	+0.10						J.
				Mean	+1.06860							
*0.449	P. B. M. 223	208 T. B. M		Dir	+1.2527	−0.85	0.6	11.2	200.7325	658.577	−2.47	J.
				Rev	+1.2510	+0.85						J.
				Mean	+1.25185							
1.148	T. B. M. 209	208 T. B. M	294.63	Dir	−0.5245	+0.15	0.1	11.2	198.9561	652.749	−2.70	J.
				Rev	−0.5242	−0.15						J.
				Mean	−0.52435							
2.195	T. B. M. 210	209 T. B. M	296.83	1. Dir	+0.2659	+3.78	0.9	11.3	199.2258	653.634	−2.67	F.
				1. Rev	+0.2722	−2.52						F.
				2. Dir	+0.2709	−1.22						F.
				2. Rev	+0.2697	−0.02						F.
				Mean	+0.26968							
1.685	T. B. M. 211	210 T. B. M	298.51	1. Dir	−0.3177	−2.13	1.0	11.3	198.9060	652.585	−2.71	J.
				1. Rev	−0.3227	+2.87						J.
				2. Rev	−0.3191	−0.73						J.
				Mean	−0.31983							
*0.134	P. B. M. 224	211 T. B. M		Dir	−0.7682	0.00	0.0	11.3	198.1377	650.064	−2.80	J.
				Rev	−0.7682	0.00						J.
				Mean	−0.76820							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r. ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
*0.134	P. B. M. 225	211 T. B. M.		Dir	+0.4499	+0.15	0.1	11.3	199.3561	654.061	—2.65	J.
				Rev	+0.4502	—0.15						J.
				Mean	+0.45005							
0.753	T. B. M. 212	211 T. B. M.	299.27	Dir	+0.7107	+0.25	0.2	11.3	199.6170	654.917	—2.62	J.
				Rev	+0.7112	—0.25						J.
				Mean	+0.71095							
1.348	T. B. M. 213	212 T. B. M.	300.61	Dir	+0.1558	—0.50	0.3	11.3	199.7723	655.427	—2.61	F.
				Rev	+0.1548	+0.50						F.
				Mean	+0.15530							
1.968	T. B. M. 214	213 T. B. M.	302.58	Dir	—1.2490	+0.50	0.3	11.3	198.5237	651.330	—2.75	F.
				Rev	—1.2480	—0.50						F.
				Mean	—1.24850							
1.124	T. B. M. 215	214 T. B. M.	303.71	Dir	—0.6484	+1.25	0.8	11.4	197.8764	649.207	—2.83	F.
				Rev	—0.6459	—1.25						F.
				Mean	—0.64715							
*0.025	P. B. M. 226	215 T. B. M.		Dir	+0.4899	—0.05	0.0	11.4	198.3664	650.814	—2.77	J.
				Rev	+0.4898	+0.05						J.
				Mean	+0.48985							
*0.025	P. B. M 227	215 T. B. M.		Dir	+1.7096	0.00	0.0	11.4	199.5862	654.816	—2.63	J.
				Rev	+1.7096	0.00						J.
				Mean	+1.70960							
1.454	T. B. M. 216	215 T. B. M.	305.16	Dir	+1.4034	—0.80	0.5	11.4	199.2792	653.809	—2.67	J.
				Rev	+1.4018	+0.80						J.
				Mean	+1.40260							

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0.014	P. B. M. 228	216 T. B. M.		Dir	+0.5104	+0.30	0.2	11.4	199.7900	655.485	—2.61	J.
				Rev	+0.5110	—0.30						J.
				Mean	+0.51070							
1.284	T. B. M. 217	216 T. B. M.	306.44	Dir	—0.8898	+2.15	1.4	11.5	198.3914	650.896	—2.77	J.
				Rev	—0.8855	—2.15						J.
				Mean	—0.88765							
1.250	T. B. M. 218	217 T. B. M.	307.69	Dir	+0.3285	+1.40	0.9	11.5	198.7214	651.979	—2.73	J.
				Rev	+0.3313	—1.40						J.
				Mean	+0.32990							
1.420	T. B. M. 219	218 T. B. M	309.11	Dir	+1.0732	+1.50	1.0	11.5	199.7962	655.505	—2.61	F.
				Rev	+1.0762	—1.50						F.
				Mean	+1.07470							
0.646	T. B. M. 220	219	309.76	Dir	—0.1672	+0.10	0.1	11.5	190.6291	654.957	—2.62	F.
				Rev	—0.1670	—0.10						F.
				Mean	—0.16710							
*0.061	P. B. M. 220	220 T. B. M.		Dir	—1.3590	—0.10	0.1	11.5	198.2698	650.497	—2.78	F.
				Rev	—1.3592	+0.10						F.
				Mean	—1.35910							
0.061	P. B. M. 230	220 T. B. M.		Dir	—0.1410	+0.15	0.1	11.5	199.4882	654.495	—2.64	F.
				Rev	—0.1407	—0.15						F.
				Mean	—0.14085							
1.661	T. B. M. 221 and 222a	220 T. B. M.	311.42	Dir	—1.8874	—0.85	0.6	11.6	197.7406	648.761	—2.84	F.
				Rev	—1.8891	+0.85						F.
				Mean	—1.88825							
1.510	T. B. M. 222 and 222a	221 and a T. B. M	312.93	Dir	—0.1391	+0.25	0.2	11.6	197.6018	648.306	—2.87	J.
				Rev	—0.1386	—0.25						J.
				Mean	—0.13885							
1.744	T. B. M. 223 and 223a	222 and a T. B. M.	314.67	Dir	+2.1327	+1.05	0.7	11.6	199.7358	655.307	—2.61	J.
				Rev	+2.1348	—1.05						J.
				Mean	+2.13375							

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Results of precise leveling, St. Paul, Minn., to Saranna, Ill., May 1, 1891. to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.314	T. B. M. 224	223 and *a* T. B. M.	315.99	Dir	−0.4164	+0.20	0.1	11.6	199.3195	653.941	−2.65	J.
				Rev	−0.4160	−0.20						J.
				Mean	−0.41620							
1.425	T. B. M. 225	224 T. B. M	317.41	Dir	+1.6151	+0.30	0.2	11.6	200.9351	659.242	−2.46	F.
				Rev	+1.6157	−0.30						F.
				Mean	+1.61540							
0.060	P. B. M. 231	225 T. B. M.		Dir	+1.2953	−0.05	0.0	11.6	202.2305	663.492	−2.31	F.
				Rev	+1.2952	+0.05						F.
				Mean	+1.29525							
1.365	P. B. M. 232	225 T. B. M.	318.78	Dir	−2.4817	−1.80	1.2	11.7	198.4513	651.093	−2.76	F.
				Rev	−2.4853	+1.80						F.
				Mean	−2.48350							
*0.012	Old B. M. "a"	232 P. B. M.		Dir	+0.0002	−0.05	0.0	11.7	198.4515	651.093	−2.76	F.
				Rev	+0.0001	+0.05						F.
				Mean	+0.00015							
*0.094	U. S. gauge, zero of "Prairie du Chien"	232 P. B. M		Dir	−7.9270			11.7	190.5234	625.082	−3.70	F.
				Mean	−7.92700							
0.640	T. B. M. 226	232 P. B. M.	319.42	Dir	−1.5389	−0.65	0.4	11.7	196.9116	646.041	−2.94	F.
				Rev	−1.5402	+0.65						F.
				Mean	−1.53955							
2.415	T. B. M. 227	226 T. B. M.	321.83	Dir	−1.6132	+1.10	0.7	11.7	195.2993	640.751	−3.14	F.
				Rev	−1.6110	−1.10						F.
				Mean	−1.61210							

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*0.202	P. B. M. 233	227 T. B. M.		Dir	+3.2195	−0.05	0.0	11.7	198.5191	651.315	−2.75	J.
				Rev	+3.2194	+0.05						J.
				Mean	+3.21945							
*0.238	U. S. gauge, zero of (N. McGregor)	227 P. B. M		Dir	−4.8375	−0.40	0.3	11.7	190.4608	624.877	−3.71	F.
				Rev	−4.8383	+0.40						F.
				Mean	−4.83790							
1.900	T. B. M. 228	227 T. B. M	323.82	Dir	+2.4697	+1.35	0.9	11.7	197.7706	648.859	−2.84	J.
				Rev	+2.4724	−1.35						J.
				Mean	+2.47105							
0.177	P. B. M. 234	228 T. B. M		Dir	+0.8590	−0.35	0.2	11.7	198.6294	651.677	−2.74	F.
				Rev	+0.8583	+0.35						F.
				Mean	+0, 85865							
*0.096	P. B. M. 235	234 P. B. M		Dir	+0.3501	+0.05	0.0	11.7	198.9796	652.826	−2.70	F.
				Rev	+0.3502	−0.05						F.
				Mean	+0.35015							
1.508	T. B. M. 229	228 T. B. M	325.33	Dir	+0.6090	−1.30	0.9	11.7	198.3784	650.854	−2.77	J.
				Rev	+0.6064	+1.30						J.
				Mean	+0.60770							
1.438	T. B. M. 230	229 T. B. M	326.77	Dir	+0.4049	+0.35	0.2	11.7	198.7837	652.183	−2.73	J.
				Rev	+0.4056	−0.35						J.
				Mean	+0.40525							
*0.033	P. B. M. 236	230 T. B. M		Dir	−1.3396	+0.15	0.1	11.7	197.4441	647.788	−2.88	F.
				Rev	−1.3393	−0.15						F.
				Mean	−1.33945							
*0.033	P. B. M. 237	230 T. B. M		Dir	−0.1198	−0.05	0.0	11.7	198.6638	651.790	−2.74	F.
				Rev	−0.1199	+0.05						F.
				Mean	−0.11985							
2.225	T. B. M. 231	230 T. B. M	328.99	Dir	−1.4049	+0.45	0.3	11.7	197.3791	647.575	−2.89	F.
				Rev	−1.4040	−0.45						F.
				Mean	−1.40445							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
*0.026	P. B. M. 238	231 T. B. M		Dir	+2.5323	+0.05	0.0	11.7	199.9117	655.884	−2.58	F.
				Rev	+2.5324	−0.05						F.
				Mean	+2.53235							
0.908	T. B. M. 232	231 T. B. M	329.90	Dir	−0.8368	+0.80	0.5	11.8	196.5430	644.832	−2.99	F.
				Rev	−0.8352	−0.80						F.
				Mean	−0.83600							
1.180	T. B. M. 233	232 T. B. M	331.08	Dir	+1.7016	−1.10	0.7	11.8	198.2437	650.412	−2.78	J.
				Rev	+1.6994	+1.10						J.
				Mean	+1.70050							
1.860	T. B. M. 234	233 T. B. M	332.94	Dir	−0.6689	+0.50	0.3	11.8	197.5752	648.218	−2.87	J.
				Rev	−0.6679	−0.50						J.
				Mean	−0.66840							
0.370	T. B. M. 235	234 T. B. M	333.31	1. Dir	+0.1462	−0.85	0.3	11.8	197.7206	648.695	−2.84	F.
				1. Rev	+0.1443	+1.05						F.
				2. Dir	+0.1457	−0.35						F.
				2. Rev	+0.1452	+0.15						F.
				Mean	+0.14535							
*0.018	P. B. M. 229	235 T. B. M		Dir	−1.2650	+0.05	0.0	11.8	196.4555	644.545	−3.00	F.
				Rev	−1.2649	−0.05						F.
				Mean	−1.26495							
*0.018	P. B. M. 240	235 T. B. M		Dir	−0.0475	+0.10	0.1	11.8	197.5732	648.540	−2.86	F.
				Rev	−0.0473	−0.10						F.
				Mean	−0.04740							
1.258	T. B. M. 236	235 T. B. M	334.57	1. Dir	−0.7323	−0.82	1.0	11.8	196.9874	646.290	−2.94	F.
				1. Rev	−0.7368	+3.68						F.
				2. Dir	−0.7297	−3.42						F.

				2. Rev	−0.7337	+0.58						F.
				Mean	−0.73312							
1.512	T. B. M. 237	236 T. B. M	336.08	Dir Rev	+0.9193 +0.9199	+0.30 −0.30	0.2	11.8	197.9071	649.307	−2.83	J. J.
				Mean	+0.91960							
1.164	T. B. M. 238	237 T. B. M	337.25	Dir Rev	−0.5907 −0.5886	+1.05 −1.05	0.7	11.9	197.3174	647.373	−2.89	J. J.
				Mean	−0.58965							
0.890	Old B. M. "b"	238 T. B. M	338.14	Dir Rev	−1.4716 −1.4737	−1.05 +1.05	0.7	11.9	195.8445	642.540	−3.07	F. F.
				Mean	−1.47265							
0.160	Old B. M. 27, on depot	"b" B. M	338.30	Dir Rev	+1.0962 +1.0956	−0.30 +0.30	0.2	11.9	196.9406	646.136	−2.94	F. F.
				Mean	+1.09590							
*0.284	P. B. M. 241	B. M. old		Dir Rev	+7.3658 +7.3659	+0.05 −0.05	0.0	11.9	204.3073	670.306	−2.07	F. F.
				Mean	+7.36585							
1.779	T. B. M. 239	B. M. old	340.08	Dir Rev	+1.8039 +1.8015	−1.20 +1.20	0.8	11.9	198.7435	652.051	−2.73	F. F.
				Mean	+1.80270							
1.816	T. B. M. 240	239 T. B. M	341.89	Dir Rev	−0.1755 −0.1746	+0.45 −0.45	0.3	11.9	198.5684	651.477	−2.75	F. F.
				Mean	−0.17505							
1.207	T. B. M. 241	240 T. B. M	343.10	Dir Rev	−0.9693 −0.9661	+1.60 −1.60	1.1	12.0	197.6006	648.302	−2.87	F. F.
				Mean	−0.96770							
0.012	P. B. M. 242	241 T. B. M		Dir Rev	+0.7212 +0.7213	+0.05 −0.05	0.0	12.0	198.3219	650.668	−2.77	F. F.
				Mean	+0.72125							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
0.455	T. B. M. 242	241 T. B. M	343.55	Dir	−2.1382	+0.15	0.1	12.0	195.4623	641.286	−3.12	F.
				Rev	−2.1379	−0.15						F.
				Mean	−2.13805							
2.390	T. B. M. 243	242 T. B. M	345.94	1. Dir	−2.4833	+2.00	1.0	12.0	192.9816	633.147	−3.42	J.
				1. Rev	−2.4795	−0.90						J.
				2. Dir	−2.4784	−2.00						
				Mean	−2.48040							
0.330	T. B. M. 244	243 T. B. M	346.27	Dir	+3.8235	+0.60	0.4	12.0	196.8061	645.695	−2.96	J.
				Rev	+3.8247	−0.60						J.
				Mean	+3.82410							
*0.025	P. B. M. 243	244 T. B. M		Dir	−1.7360	−0.20	0.1	12.0	195.0697	639.998	−3.17	J.
				Rev	−1.7364	+0.20						J.
				Mean	−1.73620							
*0.025	P. B. M. 244	244 T. B. M		Dir	−0.5152	−0.35	0.2	12.0	196.2905	644.003	−3.02	J.
				Rev	−0.5159	+0.35						J.
				Mean	−0.51555							
1.162	T. B. M. 245	244 T. B. M	347.43	Dir	−0.8217	+0.65	0.4	12.0	195.9850	643.001	−3.06	J.
				Rev	−0.8204	−0.65						J.
				Mean	−0.82105							
.958	T. B. M. 246	245 T. B. M	348.39	1. Dir	+0.1678	+2.45	0.7	12.0	196.1553	643.560	−3.04	J.
				1. Rev	+0.1719	−1.65						J.
				2. Dir	+0.1721	−1.85						J.
				2. Rev	+0.1692	+1.05						J.
				Mean	+0.17025							

1.835	T. B. M. 247	246 T. B. M	350.23	Dir	−2.1753	+0.55	0.4	12.0	193.9802	636.424	−3.30	F.
				Rev	−2.1742	−0.55						F.
				Mean	−2.17475							
*0.112	P. B. M. 245	247 T. B. M		Dir	+0.3339	−0.05	0.0	12.0	194.3142	637.519	−3.25	F.
				Rev	+0.3338	+0.05						F.
				Mean	+0.33385							
0.112	*P. B. M. 246	247 T. B. M		Dir	+1.5511	0.00	0.0	12.0	195.5315	641.513	−3.11	F.
				Rev	+1.5511	0.00						F.
				Mean	+1.55110							
1.764	T. B. M. 248	247 T. B. M	351.99	Dir	−0.6295	−0.30	0.2	12.0	193.3504	634.357	−3.37	F.
				Rev	−0.6301	+0.30						F.
				Mean	−0.62980							
1.806	T. B. M. 249	248 T. B. M	353.80	Dir	+2.2220	+1.85	1.2	12.1	195.5745	641.654	−3.11	J.
				Rev	+2.2257	−1.85						J.
				Mean	+2.22385							
*0.258	P. B. M. 247	249 T. B. M		1. Dir	+3.0234	−0.83	0.4	12.1				J.
				1. Rev	+3.0214	+1.17			198.5974	651.572	−2.75	J.
				2. Dir	+3.0229	−0.33						J.
				Mean	+3.02257							
*0.275	P. B. M. 248	247 P. B. M		1. Dir	+2.0148	−1.17	0.4	12.1	200.6113	658.179	−2.50	J.
				1. Rev	+2.0127	+0.93						J.
				2. Rev	+2.0134	+0.23						J.
				Mean	+2.01363							
0.885	T. B. M. 250	249 T. B. M	354.68	1. Dir	−1.6404	+2.10	0.6	12.1	193.9360	636.279	−3.30	J.
				1. Rev	−1.6365	−1.80						J.
				2. Dir	−1.6390	+0.70						J.
				2. Rev	−1.6373	−1.00						J.
				Mean	−1.63830							
1.434	T. B. M. 251	250 T. B. M	356.11	Dir	+0.7649	+0.75	0.5	12.1	194.7017	638.791	−3.21	F.
				Rev	+0.7664	−0.75						F.
				Mean	+0.76565							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From—	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
0.682	T. B. M. 252	252 T. B. M	356.80	Dir	+1.2704	+0.80	0.5	12.1	195.9731	642.962	—3.06	J.
				Rev	+1.2720	—0.80						J.
				Mean	+1.27120							
*0.018	P. B. M. 249	251 T. B. M		Dir	—1.8726	—0.05	0.0	12.2	194.1002	636.817	—3.28	F.
				Rev	—1.8727	+0.05						F.
				Mean	—1.87265							
0.018	P. B. M. 250	252 T. B. M		Dir	—0.6548	—0.15	0.1	12.2	195.3181	640.813	—3.13	F.
				Rev	—0.6551	+0.15						F.
				Mean	—0.65495							
1.795	T. B. M. 253	252 T. B. M	358.59	Dir	—0.2350	+0.25	0.2	12.2	195.7383	642.192	—3.08	F.
				Rev	—0.2345	—0.25						F.
				Mean	—0.23475							
2.416	T. B. M. 254	253 T. B. M	361.01	Dir	+2.5812	+0.40	0.3	12.2	198.3202	650.663	—2.77	F.
				Rev	+2.5820	—0.40						F.
				Mean	+2.58160							
1.508	T. B. M. 255	254 T. B. M	362.52	Dir	+0.7048	+1.55	1.0	12.2	199.0267	652.981	—2.69	J.
				Rev	+0.7079	—1.55						J.
				Mean	+0.70635							
1.382	T. B. M. 256	255 T. B. M	363.90	Dir	—2.5411	+1.40	0.9	12.2	196.4866	644.647	—3.00	J.
				Rev	—2.5383	—1.40						J.
				Mean	—2.53970							
*0.012	P. B. M. 251	256 T. B. M		Dir	+0.5246	—0.15	0.1	12.2	197.0112	646.368	—2.93	J.
				Rev	+0.5243	+0.15						J.
				Mean	+0.52445							

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0.476	T. B. M. 257	256 T. B. M	364.37	1. Dir	—2.4947†	—2.90	0.2	12.2	193.9888	636.452	—3.30	F.
				1. Rev	—2.4979	+0.30						F.
				2. Dir	—2.4973	—0.30						F.
				Mean	2.49760							
*0.012	P. B. M. 252	257 T. B. M		Dir	+0.0035	+0.20	0.1	12.2	193.9924	636.464	—3.30	F.
				Rev	+0.0039	—0.20						F.
				Mean	+0.00370							
0.870	T. B. M. 258	257 T. B. M	365.24	Dir	+2.0212	+0.35	0.2	12.2	196.[illegible]06	643.085	—3.05	F.
				Rev	+2.0219	—0.35						F.
				Mean	+2.02155							
0.829	T. B. M. 259	258 T. B. M	366.07	Dir	—0.8010	+0.40	0.3	12.2	195.2098	640.458	—3.15	F.
				Rev	—0.8002	—0.40						F.
				Mean	—0.80060							
1.490	T. B. M. 260	259 T. B. M	367.56	Dir	—1.2684	—0.05	0.0	12.2	193.9412	636.296	—3.30	J.
				Rev	—1.2685	+0.05						J.
				Mean	—1.26845							
1.060	T. B. M. 261	260 T. B. M	368.62	Dir	+1.4236	+0.55	0.4	12.2	195.3656	640.969	—3.13	J.
				Rev	+1.4247	—0.55						J.
				Mean	+1.42415							
*0.072	P. B. M. 253	261 T. B. M		Dir	—1.1865	—0.05	0.0	12.2	194.1789	637.076	—3.27	J.
				Rev	—1.1866	+0.05						J.
				Mean	—1.18655							
*0.072	P. B. M. 254	261 T. B. M		Dir	+0.0324	+0.10	0.1	12.2	195.3981	641.076	—3.13	J.
				Rev	+0.0326	—0.10						J.
				Mean	+0.03250							
1.168	T. B. M. 262	261 T. B. M	369.79	Dir	+1.4234	+0.65	0.4	12.2	196.7808	645.642	—2.96	J.
				Rev	+1.4247	—0.65						J.
				Mean	+1.42405							
0.840	T. B. M. 263	262 T. B. M	370.63	Dir	—0.3421	+1.40	0.9	12.2	196.4490	644.523	—3.00	F.
				Rev	—0.3393	—1.40						F.
				Mean	—0.34070							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
0.945	T. B. M. 264	263 T. B. M	371.58	Dir	+0.8006	+1.10	0.7	12.3	197.2508	647.154	−2.90	F.
				Rev	+0.8028	−1.10						F.
				Mean	+0.80170							
*0.058	P. B. M. 255	264 T. B. M		Dir	+0.0972	0.00	0.0	12.3	197.3481	647.473	−2.89	F.
				Rev	+0.0972	0.00						F.
				Mean	+0.09720							
1.200	T. B. M. 265	264 T. B. M	372.78	Dir	+0.2941	−0.20	0.1	12.3	197.5448	648.119	−2.87	F.
				Rev	+0.2937	+0.20						F.
				Mean	+0.29390							
0.821	T. B. M. 266	265 T. B. M	373.60	Dir	−1.2972	−0.75	0.5	12.3	196.2467	643.860	−3.02	F.
				Rev	−1.2987	+0.75						F.
				Mean	−1.29795							
1.146	T. B. M. 267	266 T. B. M	374.74	Dir	+1.1534	+1.30	0.9	12.3	197.4015	647.649	−2.89	J.
				Rev	+1.1560	−1.30						J.
				Mean	+1.15470							
0.134	T. B. M. 268	267 T. B. M	374.88	1. Dir	+0.2207	−0.83	0.3	12.3	197.6214	648.370	−2.86	J.
				1. Rev	+0.2194	+0.47						J.
				2. Dir	+0.2195	+0.37						J.
				Mean	+0.21987							
*0.046	P. B. M. 256	268 T. B. M		Dir	−1.4126	+0.05	0.0	12.3	196.2087	643.735	−3.04	F.
				Rev	−1.4125	−0.05						F.
				Mean	−1.41255							
*0.046	P. B. M. 257	268 T. B. M		Dir	−0.1936	0.00	0.0	12.3	107.4278	647.735	−2.88	F.
				Rev	−0.1936	0.00						F.
				Mean	−0.19360							

0.754	T. B. M. 269	268 T. B. M	375.63	Dir	+0.3114	−0.95	0.6	12.3	197.9319	649.389	−2.82	J.
				Rev	+0.3095	+0.95						J.
				Mean	+0.31045							
1.606	T. B. M. 270	269 T. B. M	377.24	Dir	−0.9557	−0.35	0.2	12.8	196.9757	646.252	−2.94	F.
				Rev	−0.9564	+0.35						F.
				Mean	−0.95605							
0.710	T. B. M. 271	270 T. B. M	377.95	Dir	−0.9181	+0.50	0.3	12.8	196.0580	643.241	−3.05	F.
				Rev	−0.9171	−0.50						F.
				Mean	−0.91760							
*0.094	P. B. M 258	271 T. B. M		1. Dir	−2.2708	+0.58	0.2	12.3	193.7875	635.791	−3.32	F.
				1. Rev	−2.2692	−1.02						F.
				2. Dir	−2.2717	+1.48						W.
				2. Rev	−2.2697	−0.52						W.
				3. Dir	−2.2703	+0.08						W.
				3. Rev	−2.2696	−0.62						W.
				Mean	−2.27022							
*0.094	P. B. M. 259	271 T. B. M		Dir	−1.0544	−0.25	0.2	12.3	195.0032	639.780	−3.18	F.
				Rev	−1.0549	+0.25						F.
				Mean	−1.05465							
1.282	T. B. M. 272	271 T. B. M	379.23	Dir	+0.1736	+1.20	0.8	12.4	196.2328	643.814	−3.02	J.
				Rev	+0.1760	−1.20						J.
				Mean	+0.17480							
2.038	T. B. M. 273	272 T. B. M	381.27	Dir	+0.7877	−1.50	1.0	12.4	197.0191	646.394	−2.93	F.
				Rev	+0.7847	+1.50						F.
				Mean	+0.78620							
1.800	T. B. M. 274	273 T. B. M	382.57	Dir	+0.1969	+0.90	0.6	12.4	197.2170	647.043	−2.90	F.
				Rev	+0.1987	−0.90						F.
				Mean	+0.19780							
1.150	T. B. M. 275	274 T. B. M	383.72	Dir	−2.1308	+0.15	0.1	12.4	195.0860	640.052	−3.17	J.
				Rev	−2.1305	−0.15						J.
				Mean	−2.13065							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
*0.072	P. B. M. 260	275 T. B. M		Dir	−0.3773	+ 0.05	0.0	12.4	194.7088	638.814	−3.21	F.
				Rev	−0.3772	− 0.05						F.
				Mean	−0.37725							
*0.072	P. B. M. 261	275 T. B. M		Dir	+0.8422	+ 0.15	0.1	12.4	195.9285	642.816	−3.06	F.
				Rev	+0.8425	− 0.15						F.
				Mean	+0.84235							
1.170	P. B. M. 262	275 T. B. M	384.89	Dir	−1.3666	− 1.00	0.7	12.4	193.7183	635.564	−3.32	F.
				Rev	−1.3686	+ 1.00						F.
				Mean	−1.36760							
1.658	T. B. M. 276	262 P. B. M	386.54	Dir	+0.0583	− 0.50	0.3	12.4	193.7761	635.754	−3.32	J.
				Rev	+0.0573	+ 0.50						J.
				Mean	+0.05780							
1.460	T. B. M. 277	276 T. B. M	388.00	Dir	−0.5526	− 0.60	0.4	12.5	193.2228	633.939	−3.38	J.
				Rev	−0.5538	+ 0.60						J.
				Mean	−0.55320							
*0.022	P. B. M. 263	277 T. B. M		Dir	−0.9513	− 0.10	0.1	12.5	192.2713	630.817	−3.50	F.
				Rev	−0.9515	+ 0.10						F.
				Mean	−0.95140							
*0.022	P. B. M. 264	277 T. B. M		Dir	+0.2678	− 0.10	0.1	12.5	193.4906	634.817	−3.36	F.
				Rev	+0.2676	+ 0.10						F.
				Mean	+0.26770							
1.341	T. B. M. 278	277 T. B. M	389.35	Dir	+0.9950	+ 1.05	0.7	12.5	194.2190	637.207	−3.26	F.
				Rev	+0.9971	− 1.05						F.
				Mean	+0.99605							

0.858	Old B. M. 30, on doorstep of Specht's House.	278 T. B. M	390.20	Dir	—0.5543	+ 0.35	0.2	12.5	193.6650	635.390	—3.33	F.
				Rev	—0.5536	— 0.35						F.
				Mean	—0.55395							
*0.014	Old B. M. "A"	B. M. old		Dir	+0.1450	— 0.05	0.0	12.5	193.8100	635.865	—3.31	F.
				Rev	+0.1449	+ 0.05						F.
				Mean	+0.14495							
*0.060	P. B. M. 265	B. M. old		Dir	—1.2318	— 0.10	0.1	12.5	192.4329	631.347	—3.48	F.
				Rev	—1.2320	+ 0.10						F.
				Mean	—1.23190							
*0.060	P. B. M. 266	B. M. old		Dir	—0.0135	+ 0.05	0.0	12.5	193.6515	635.345	—3.33	F.
				Rev	—0.0134	— 0.05						F.
				Mean	—0.01345							
0.597	T. B. M. 279	B. M. old	390.80	1. Dir	+0.7456	+ 0.13	0.1	12.5	194.4108	637.836	—3.24	F.
				1. Rev	+0.7459	— 0.17						J.
				2. Rev	+0.7457	+ 0.03						J.
				Mean	+0.74573							
1.894	T. B. M. 280	279 T. B. M	392.69	1. Dir	+0.1984	+ 3.70	1.0	12.5	194.6129	638.499	—3.21	J.
				1. Rev	+0.1912	+10.90						J.
				2. Dir	+0.2054	— 3.30						J.
				2. Rev	+0.2038	— 1.70						J.
				3. Dir	+0.2008	+ 1.30						J.
				Mean	+0.20210							
*0.042	P. B. M. 267	280 T. B. M		Dir	—2.7410	0.00	0.0	12.5	191.8716	629.506	—3.55	F.
				Rev	—2.7410	0.00						F.
				Mean	—2.7410							
*0.042	P. B. M. 268	280 T. B. M		Dir	—1.5183	+ 0.15	0.1	12.5	193.0946	633.518	—3.40	F.
				Rev	—1.5180	— 0.15						F.
				Mean	—1.51815							
1.282	T. B. M. 281 and 281 a	280 T. B. M	393.98	Dir	—1.4129	— 0.65	0.4	12.5	193.1992	633.861	—3.39	F.
				Rev	—1.4142	+ 0.65						F.
				Mean	—1.41355							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.175	T. B. M. 282	281 and a T. B. M.	395.15	Dir	+0.0989	−0.10	0.1	12.5	193.2980	634.185	−3.38	F.
				Rev	+0.0987	+0.10						F.
				Mean	+0.09880							
*0.018	P. B. M. 269	282 T. B. M.		Dir	+1.1695	0.00	0.0	12.5	194.4677	638.023	−3.24	F.
				Rev	+1.1695	0.00						F.
				Mean	+1.16950							
*0.018	P. B. M 270	282 T. B. M		Dir	+2.3963	0.00	0.0	12.5	195.6946	642.048	−3.09	F.
				Rev	+2.3963	0.00						F.
				Mean	+2.39630							
1.080	T. B. M. 283	282 T. B. M	396.23	Dir	+0.7124	−0.95	0.6	12.6	194.0096	636.520	−3.30	F.
				Rev	+0.7105	+0.95						F.
				Mean	+0.71145							
1.353	T. B. M. 284	283 T. B. M	397.58	Dir	−0.4905	0.00	0.0	12.6	193.5190	634.911	−3.34	J.
				Rev	−0.4905	0.00						J.
				Mean	−0.49050							
1.354	T. B. M. 285	284 T. B. M	398.94	Dir	+0.2259	+0.60	0.4	12.6	193.7455	635.654	−3.32	J.
				Rev	+0.2271	−0.60						J.
				Mean	+0.22650							
*0.014	P. B. M. 271	285 T. B. M		Dir	−1.0418	−0.10	0.1	12.6	192.7035	632.235	−3.45	J.
				Rev	−1.0420	+0.10						J.
				Mean	−1.04190							
*0.014	P. B. M. 272	285 T. B. M		Dir	+0.1770	−0.20	0.1	12.6	193.9224	636.234	−3.30	J.
				Rev	+0.1766	+0.20						J.
				Mean	+0.17680							

1.338	T. B. M. 286 and 286a	285 T. B. M	400.28	Dir	—0.3557	+2.20	1.5	12.6	193.3920	634.494	—3.37	F.
				Rev	—0.3513	—2.20						F.
				Mean	—0.35350							
1.554	T. B. M. 287	286 & a T. B. M	401.83	Dir	—0.9641	—0.35	0.2	12.6	192.4274	631.329	—3.48	F.
				Rev	—0.9648	+0.35						F.
				Mean	—0.96445							
*0.020	P. B. M. 273	287 T. B. M		Dir	—0.9513	—0.15	0.1	12.6	191.4759	628.207	—3.59	J.
				Rev	—0.9516	+0.15						J.
				Mean	—0.95145							
*0.020	P. B. M. 274	287 T. B. M		Dir	+0.2662	—0.20	0.1	12.6	192.6934	632.202	—3.45	J.
				Rev	+0.2658	+0.20						J.
				Mean	+0.26600							
0.840	T. B. M. 288	287 T. B. M	402.67	1. Dir	+0.8454	—2.95	0.8	12.6	193.2700	634.094	—3.38	J.
				1. Rev	+0.8413	+1.15						J.
				2. Dir	+0.8402	+2.25						J.
				2. Rev	+0.8429	—0.45						J.
				Mean	+0.84245							
0.742	T. B. M. 289	288 T. B. M	403.41	Dir	+1.2707	+1.75	1.2	12.7	194.5426	638.269	—3.22	J.
				Rev	+1.2742	—1.75						J.
				Mean	+1.27245							
1.205	T. B. M. 290	289 T. B. M	404.62	Dir	—1.5917	+0.25	0.2	12.7	192.9509	633.047	—3.42	F.
				Rev	—1.5912	—0.25						F.
				Mean	—1.59145							
0.984	T. B. M. 291	290 T. B. M.	405.60	Dir	—1.3008	+0.35	0.2	12.7	191.6503	628.780	—3.57	F.
				Rev	—1.3001	—0.35						F.
				Mean	—1.30045							
*0.058	P. B. M. 275	291 T. B. M.		Dir	—0.9104	—0.15	0.1	12.7	190.7397	625.792	—3.68	F.
				Rev	—0.9107	+0.15						F.
				Mean	—0.91055							
*0.368	P. B. M. 276	291 T. B. M.		Dir	—0.2589	+0.95	0.6	12.7	191.3923	627.933	—3.61	F.
				Rev	—0.2570	—0.95						F.
				Mean	—0.25795							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
*0.368	P. B. M. 277	291 T. B. M.		Dir	+ 0.9583	+1.00	0.7	12.7	192.6098	631.928	—3.45	F.
				Rev	+ 0.9603	—1.00						F.
				Mean	+ 0.95930							
*0.444	Old B. M. "23"	291 T. B. M.		Dir	— 4.3692	+0.35	0.2	12.7	187.2810	614.444	—4.09	F.
				Rev	— 4.3685	—0.35						F.
				Mean	— 4.36885							
0.930	T. B. M. 292 and 292 *a*	291 T. B. M.	406.58	Dir	+ 0.1436	+0.55	0.4	12.7	191.7945	629.253	—3.56	F.
				Rev	+ 0.1447	—0.55						F.
				Mean	+ 0.14415							
1.530	T. B. M. 293	292 and *a* T. B. M.	408.06	Dir	+ 0.5330	—1.05	0.7	12.8	192.3265	630.998	—3.49	F.
				Rev	+ 0.5309	+1.05						F.
				Mean	+ 0.53195							
0.775	T. B. M. 294	293 T. B. M.	408.84	Dir	— 0.4842	+0.45	0.3	12.8	191.8427	629.411	—3.55	F.
				Rev	— 0.4833	—0.45						F.
				Mean	— 0.48375							
*0.015	P. B. M. 278	294 T. B. M.		Dir	+ 0.0384	—0.15	0.1	12.8	191.8810	629.536	—3.55	F.
				Rev	+ 0.0381	+0.15						F.
				Mean	+ 0.03825							
0.675	T. B. M. 295	294 T. B. M.	409.51	Dir	— 0.5936	—1.10	0.7	12.8	191.2479	627.459	—3.62	J.
				Rev	— 0.5958	+1.10						J.
				Mean	— 0.59470							
*0.634	P. B. M. 279	295 T. B. M.		Dir	+11.3648	—0.35	0.2	12.8	202.6137	664.749	—2.26	F.
				Rev	+11.3641	+0.35						F.
				Mean	+11.36445							

*0.799	P. B. M. 280	295 T. B. M.		1. Dir	+ 3.2201	−2.17	0.7	12.8	194.4662	638.018	−3.24	F.
				1. Rev	+ 3.2166	+1.33						F.
				2. Rev	+ 3.2171	+0.83						F.
				Mean	+ 3.21793							
*0.555	Old B. M. "a" in East Dubuque	280 P. B. M.		Dir	− 0.8737	−0.75	0.5	12.8	193.5917	635.149	−3.34	F.
				Rev	− 0.8752	+0.75						F.
				Mean	− 0.87445							
....	Old B. M. "b" in East Dubuque	"a" B. M.		Dir	− 0.2230	−0.15	0.1	12.8	193.3685	634.417	−3.37	F.
				Rev	− 0.2233	+0.15						F.
				Mean	− 0.22315							
*0.172	U. S. gauge zero of East Dubuque	"a" B. M.		Dir	− 9.3102	−0.25	0.2	12.8	184.2801	604.599	−4.45	F.
				Rev	− 9.3107	+0.25						F.
				Mean	− 9.31045							
0.640	T. B. M. 296	295 T. B. M.	410.15	Dir	+ 0.2573	−0.30	0.2	12.8	191.5050	628.303	−3.59	J.
				Rev	+ 0.2567	+0.30						J.
				Mean	+ 0.25700							
*0.327	City B. M. on Julien House	296 T. B. M.		Dir	+ 1.2901	+0.25	0.2	12.8	192.7955	632.537	−3.44	F.
				Rev	+ 1.2906	−0.25						F.
				Mean	+ 1.29035							
*0.259	City B. M. on Jess' store	B. M., City		Dir	− 1.1126	−0.05	0.0	12.8	191.6827	628.886	−3.57	F.
				Rev	− 1.1127	+0.05						F.
				Mean	− 1.11265							
0.635	T. B. M. 297	296 T. B. M.	410.70	Dir	− 0.0249	−0.40	0.3	12.8	191.4797	628.220	−3.59	J.
				Rev	− 0.0257	+0.40						J.
				Mean	− 0.02530							
*0.064	Old B. M. "a" Dubuque	"6" B. M.		Dir	+ 0.3463	+0.20	0.1	12.8	191.2175	627.360	−3.62	J.
				Rev	+ 0.3467	−0.20						J.
				Mean	+ 0.34650							
*0.265	Old B. M. "6," Dubuque	297 T. B. M.		Dir	− 0.6079	−0.75	0.5	12.8	190.8709	626.222	−3.67	J.
				Rev	− 0.6094	+0.75						J.
				Mean	− 0.60865							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.480	T. B. M. 298	297 T. B. M	412.27	Dir	—1.7558	—1.50	1.0	12.8	189.7222	622.454	—3.80	F.
				Rev	—1.7588	+1.50						F.
				Mean	—1.75730							
*0.060	P. B. M. 281	298 T. B. M		Dir	+3.0228	0.00	0.0	12.8	192.7458	632.372	—3.44	F.
				Rev	+3.0228	0.00						F.
				Mean	+3.02280							
1.505	T. B. M. 299	298 T. B. M	413.77	Dir	+2.5106	—1.10	0.7	12.8	192.2320	630.688	—3.50	F.
				Rev	+2.5084	+1.10						F.
				Mean	+2.50950							
*0.014	P. B. M. 282	299 T. B. M		Dir	—0.2264	—0.10	0.1	12.8	192.0054	629.945	—3.54	F.
				Rev	—0.2266	+0.10						F.
				Mean	—0.22650							
*0.014	P. B. M. 283	299 T. B. M		Dir	+0.9924	—0.10	0.1	12.8	193.2244	633.944	—3.38	F.
				Rev	+0.9922	+0.10						F.
				Mean	+0.99230							
1.494	T. B. M. 300	299 T. B. M	415.27	Dir	+0.0306	—0.90	0.6	12.9	192.2616	630.785	—3.50	J.
				Rev	+0.0288	+0.90						J.
				Mean	+0.02970							
1.072	T. B. M. 301	300 T. B. M	416.34	Dir	+1.8043	+0.90	0.6	12.9	194.0671	636.709	—3.28	J.
				Rev	+1.8061	—0.90						J.
				Mean	+1.80520							
0.091	P. B. M. 284	301 T. B. M		Dir	—1.1510	—0.15	0.1	12.9	192.9158	632.932	—3.42	J.
				Rev	—1.1513	+0.15						J.
				Mean	—1.15115							

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*0.091	P. B. M. 285	301 T. B. M		Dir	+0.0080	−0.10	0.1	12.9	194.1350	636.932	−3.27	J.
				Rev	+0.0678	+0.10						J.
				Mean	+0.06790							
0.670	T. B. M. 302	301 T. B. M	417.01	Dir	+0.1278	0.00	0.0	12.9	194.1949	637.128	−3.27	J.
				Rev	+0.1278	0.00						J.
				Mean	+0.12780							
0.750	T. B. M. 303	302 T. B. M	417.76	Dir	−0.6634	+1.45	1.0	12.9	193.5329	634.956	−3.34	J.
				Rev	−0.6605	−1.45						J.
				Mean	−0.66195							
1.050	T. B. M. 304	303 T. B. M	418.81	Dir	−2.3614	+1.50	1.0	13.0	191.1727	627.213	−3.63	F.
				Rev	−2.3584	−1.50						F.
				Mean	−2.35990							
*0.021	Old B. M. "24"	304 T. B. M		Dir	−4.9593	−0.05	0.0	13.0	186.2127	610.940	−4.21	F.
				Rev	−4.9594	+0.05						F.
				Mean	−4.95935							
0.948	T. B. M. 305	304 T. B. M	419.76	Dir	−0.2392	+0.65	0.4	13.0	190.9841	626.430	−3.65	F.
				Rev	−0.2379	−0.65						F.
				Mean	−0.23855							
*0.034	P. B. M. 286	305 T. B. M		Dir	−1.1460	−0.10	0.1	13.0	189.7878	622.669	−3.80	F.
				Rev	−1.1462	+0.10						F.
				Mean	−1.14610							
*0.034	P. B. M. 287	305 T. B. M		Dir	+0.0729	+0.05	0.0	13.0	191.0070	626.669	−3.65	F.
				Rev	+0.0730	−0.05						F.
				Mean	+0.07295							
0.410	T. B. M. 306	305 T. B. M	420.17	Dir	+2.1082	+0.05	0.0	13.0	193.0420	633.348	−3.40	F.
				Rev	+2.1083	−0.05						F.
				Mean	+2.10825							
1.494	T. B. M. 307	306 T. B. M	421.66	Dir	−1.1459	−0.50	0.3	13.0	191.8960	629.586	−3.55	J.
				Rev	−1.1469	+0.50						J.
				Mean	−1.14640							

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.202	T. B. M. 308	307 T. B. M	422.86	Dir	—0.7944	—0.75	0.5	13.0	191.1008	626.977	—3.64	J.
				Rev	—0.7959	+0.75						J.
				Mean	—0.79515							
0.850	T. B. M. 309	308 T. B. M	423.71	Dir	+1.9758	—1.15	0.8	13.0	193.0757	633.456	—3.40	F.
				Rev	+1.9735	+1.15						F.
				Mean	+1.97465							
*0.028	P. B. M. 288	309 T. B. M		Dir	—2.9840	—0.10	0.1	13.0	190.0912	623.664	—3.76	F.
				Rev	—2.9842	+0.10						F.
				Mean	—2.98410							
*0.028	P. B. M. 289	309 T. B. M		Dir	—1.7653	0.00	0.0	13.0	191.3102	627.664	—3.61	F.
				Rev	—1.7653	0.00						F.
				Mean	—1.76530							
0.878	T. B. M. 310	309 T. B. M	424.59	Dir	+1.7758	+1.15	0.8	13.0	194.8529	639.287	—3.19	F.
				Rev	+1.7781	—1.15						F.
				Mean	+1.77695							
0.702	T. B. M. 311	310 T. B. M	425.29	Dir	—2.3907	+0.40	0.3	13.0	192.4623	631.444	—3.48	F.
				Rev	—2.3899	—0.40						F.
				Mean	—2.39030							
1.835	T. B. M. 312	311 T. B. M	427.13	Dir	—0.0203	+0.40	0.3	13.0	192.4424	631.378	—3.48	F.
				Rev	—0.0195	—0.40						F.
				Mean	—0.01990							
*0.098	P. B. M. 290	312 T. B. M		Dir	—2.1563	0.00	0.0	13.0	190.2858	624.303	—3.74	J.
				Rev	—2.1563	0.00						J.
				Mean	—2.15630							

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*0.098	P. B. M. 291	312 T. B. M		Dir	−0.9363	−0.05	0.0	13.0	191.5059	628.306	−3.59	J.
				Rev	−0.9364	+0.05						J.
				Mean	−0.93635							
1.074	T. B. M. 313	312 T. B. M	428.20	Dir	−0.9914	−0.75	0.5	13.0	191.4501	628.123	−3.59	J.
				Rev	−0.9929	+0.75						J.
				Mean	−0.99215							
2.154	T. B. M. 314	313 T. B. M	430.35	Dir	−2.7567	−1.50	1.0	13.1	188.6916	619.072	−3.93	J.
				Rev	−2.7597	+1.50						J.
				Mean	−2.75820							
*0.068	P. B. M. 292	314 T. B. M		Dir	+0.4633	−0.15	0.1	13.1	189.1548	620.582	−3.87	F.
				Rev	+0.4630	+0.15						F.
				Mean	+0.46315							
*0.068	P. B. M. 293	314 T. B. M		Dir	+1.6831	+0.15	0.1	13.1	190.3750	624.595	−3.72	F.
				Rev	+1.6834	−0.15						F.
				Mean	+1.68325							
0.762	T. B. M. 315	314 T. B. M	431.12	Dir	+3.9305	−0.70	0.5	13.1	192.6218	631.967	−3.45	J.
				Rev	+3.9291	+0.70						J.
				Mean	+3.92980							
0.814	T. B. M. 316	315 T. B. M	431.93	Dir	−1.5088	−1.15	0.8	13.1	191.1117	627.013	−3.63	F.
				Rev	−1.5111	+1.15						F.
				Mean	−1.50995							
*0.084	P. B. M. 294	316 T. B. M		Dir	+2.1915	−0.05	0.0	13.1	193.3034	634.203	−3.38	F.
				Rev	+2.1914	+0.05						F.
				Mean	+2.19145							
*0.084	P. B. M. 295	316 T. B. M		Dir	+3.4052	+0.35	0.2	13.1	194.5177	638.187	−3.22	F.
				Rev	+3.4059	+0.35						F.
				Mean	+3.40555							
1.165	T. B. M. 317	316 T. B. M	433.10	Dir	+0.5484	−0.80	0.5	13.1	191.6594	628.809	−3.57	F.
				Rev	+0.5468	+0.80						F.
				Mean	+0.54760							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.016	T. B. M. 318	317 T. B. M	434.11	Dir	+ 0.6859	0.00	0.0	13.1	192.3454	631.060	—3.49	J.
				Rev	+ 0.6859	0.00						J.
				Mean	+ 0.68590							
0.440	T. B. M. 319	318 T. B. M	434.55	Dir	+ 0.4146	+0.10	0.1	13.1	192.7601	632.421	—3.44	J.
				Rev	+ 0.4148	—0.10						J.
				Mean	+ 0.41470							
*0.048	P. B. M. 296	319 T. B. M		Dir	— 1.6265	0.00	0.0	13.1	191.1334	627.084	—3.63	J.
				Rev	— 1.6265	0.00						J.
				Mean	— 1.62650							
*0.048	P. B. M. 297	319 T. B. M		Dir	— 0.4040	0.00	0.0	13.1	192.3561	631.095	—3.49	J.
				Rev	— 0.4040	0.00						J.
				Mean	— 0.40400							
1.632	T. B. M. 320	319 T. B. M	436.18	Dir	— 1.4819	+1.75	1.2	13.2	191.2798	627.564	—3.62	J.
				Rev	— 1.4784	—1.75						J.
				Mean	— 1.48015							
1.405	T. B. M. 321	320 T. B. M	437.59	Dir	— 0.0255	+0.95	0.6	13.2	191.2552	627.483	—3.62	F.
				Rev	— 0.0236	—0.95						F.
				Mean	— 0.02455							
*0.012	P. B. M. 298	321 T. B. M		Dir	— 1.6644	+0.05	0.0	13.2	189.5907	622.022	—3.82	F.
				Rev	— 1.6643	—0.05						F.
				Mean	— 1.66435							
*0.012	P. B. M. 299	321 T. B. M		Dir	— 0.4505	+0.05	0.0	13.2	190.8047	626.005	—3.68	F.
				Rev	— 0.4504	—0.05						F.
				Mean	— 0.45045							

1.274	T. B. M. 322	321 T. B. M.	438.86	Dir	− 1.2766	−1.10	0.7	13.2	189.9774	623.291	−3.77	F.
				Rev	− 1.2788	+1.10						F.
				Mean	− 1.27770							
2.020	T. B. M. 323	322 T. B. M.	440.88	Dir	+ 1.6372	+1.65	0.8	13.2	191.6164	628.668	−3.57	F.
				Rev	+ 1.6405	−1.65						F.
				Mean	+ 1.63885							
*0.012	P. B. M. 300	323 T. B. M.		Dir	− 0.7907	−0.10	0.1	13.2	190.8255	626.074	3.67	J.
				Rev	− 0.7909	+0.10						J.
				Mean	− 0.79080							
*0.012	P. B. M. 301	323 T. B. M.		Dir	+ 0.4207	−0.05	0.0	13.2	192.0371	630.049	−3.52	J.
				Rev	+ 0.4206	+0.05						J.
				Mean	+ 0.42065							
1.990	T. B. M. 324 and 324a	323 T. B. M.	442.87	1. Dir	+ 7.7956	−0.05	0.8	13.2	199.4129	654.248	−2.64	J.
				1. Rev	+ 7.8033†	−7.75						J.
				2. Dir	+ 7.7923	+3.25						J.
				2. Rev	+ 7.7983	−2.75						J.
				3. Rev	+ 7.7960	−0.45						J.
				Mean	+ 7.79555							
1.250	P. B. M. 302	324 T. B. M.	444.12	Dir	− 2.3947	+0.10	0.1	13.2	197.0180	646.390	−2.93	J.
				Rev	− 2.3945	−0.10						J.
				Mean	− 2.39460							
*0.304	P. B. M. 303	302 P. B. M.		Dir	−10.5946	+0.65	0.4	13.2	186.4228	611.629	−4.19	J.
				Rev	−10.5933	−0.65						J.
				Mean	−10.59395							
*0.304	P. B. M. 304	302 P. B. M		Dir	− 9.3834	+0.25	0.2	13.2	187.6338	615.602	−4.05	J.
				Rev	− 9.3829	−0.25						J.
				Mean	− 9.38315							
1.957	T. B. M. 325	302 P. B. M	446.08	Dir	− 0.8062	−1.55	1.0	13.3	196.2102	643.740	−3.02	F.
				Rev	− 0.8093	+1.55						F.
				Mean	− 0.80775							

† Rejected.

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Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
*0.010	P. B. M. 314	333 T. B. M.		Dir	+ 0.6250	−0.15	0.1	13.4	186.7874	612.825	−4.15	J.
				Rev	+ 0.6247	+0.15						J.
				Mean	+ 0.62485							
0.520	T. B. M. 334	333 T. B. M.	456.27	Dir	− 3.3006	+0.25	0.2	13.4	182.8617	599.945	−4.62	J.
				Rev	− 3.3001	−0.25						J.
				Mean	− 3.30035							
*0.151	P. B. M. 315	334 T. B. M.		Dir	+ 2.3246	−0.15	0.1	13.4	185.1865	607.573	−4.34	J.
				Rev	+ 2.3243	+0.15						J.
				Mean	+ 2.32445							
*0.151	P. B. M. 316	334 T. B. M.		Dir	+ 3.5330	−0.25	0.2	13.4	186.3949	611.537	−4.20	J.
				Rev	+ 3.5325	+0.25						J.
				Mean	+ 3.53275							
0.292	T. B. M. 335	334 T. B. M.	456.56	Dir	− 0.1254	−0.40	0.3	13.4	182.7359	599.533	−4.63	F & J.
				Rev	− 0.1262	+0.40						F & J.
				Mean	− 0.12580							
0.530	T. B. M. 336	335 T. B. M.	457.19	1. Dir	− 0.5105	−1.35	0.9	13.5	182.2240	597.853	−4.69	F.
				1. Rev	− 0.5155	+3.65						F.
				2. Dir	− 0.5098	−2.05						F.
				2. Rev	− 0.5116	−0.25						F.
				Mean	− 0.51185							
1.200	T. B. M. 337	336 T. B. M.	458.39	Dir	+ 3.0535	+0.80	0.5	13.5	185.2787	607.875	−4.33	F.
				Rev	+ 3.0551	−0.80						F.
				Mean	+ 3.05430							

0.300	P. B. M. 317	337 T. B. M.		Dir	+ 7.0211	—0.15	0.1	13.5	192.3004	630.912	—3.50	F.
				Rev	+ 7.0208	+0.15						F.
				Mean	+ 7.02095							
*0.301	P. B. M. 318	337 T. B. M.		Dir	+ 8.2299	—0.15	0.1	13.5	193.5094	634.879	—3.36	F.
				Rev	+ 8.2296	+0.15						F.
				Mean	+ 8.22975							
0.301	P. B. M. 319	337 T. B. M.		Dir	+ 7.3652	—0.10	0.1	13.5	192.6446	632.042	—3.45	F.
				Rev	+ 7.3650	+0.10						F.
				Mean	+ 7.36510							
*0.301	P. B. M. 320	337 T. B. M.		Dir	+ 8.5837	—0.30	0.2	13.5	193.8631	636.040	—3.31	F.
				Rev	+ 8.5831	+0.30						F.
				Mean	+ 8.58340							
0.810	T. B. M. 338 and 338*a*	337 T. B. M.	459.20	Dir	— 1.3644	—0.60	0.4	13.5	183.9135	603.396	—4.49	J.
				Rev	— 1.3656	+0.60						J.
				Mean	— 1.36500							
1.456	T. B. M. 339	338 T. B. M.	460.66	Dir	— 0.3822	+0.60	0.4	13.5	183.5319	602.144	—4.53	J.
				Rev	— 0.3810	—0.60						J.
				Mean	— 0.38160							
*0.155	P. B. M. 321	339 T. B. M.		Dir	+11.4875	+0.30	0.2	13.5	195.0210	639.838	—3.17	J.
				Rev	+11.4881	—0.30						J.
				Mean	+11.48780							
*0.155	P. B. M. 322	339 T. B. M.		Dir	+12.7067	+0.05	0.0	13.5	196.2401	643.838	—3.02	J.
				Rev	+12.7068	—0.05						J.
				Mean	+12.70675							
0.840	T. B. M. 340	339 T. B. M.	461.50	Dir	+ 1.9162	+0.40	0.3	13.5	185.4487	608.433	—4.31	F.
				Rev	+ 1.9170	—0.40						F.
				Mean	+ 1.91660							
1.285	T. B. M. 341	340 T. B. M.	462.79	Dir	— 0.6340	—1.95	1.3	13.5	184.8127	606.346	—4.38	F.
				Rev	— 0.6379	+1.95						F.
				Mean	— 0.63595							

Results of precise leveling, St. Paul, Minn., to Savanna, Ill., May 1, 1891, to October 20, 1891—Continued.

[Bench marks marked with an asterisk are not in main line of levels. The value of one meter used = 3.2808693 feet.]

Length B. M. to B. M.	Bench marks.	From.	Distance.	Direction.	Difference of elevation.	V	r ±	R ±	Elevation above Cairo datum.		Rod cor.	Obs.
Km.			*Km.*		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*	*Mm.*	
1.065	T. B. M. 342	341 T. B. M.	463.85	Dir	+ 0.8402	—0.10	0.1	13.5	185.6529	609.103	—4.28	F.
				Rev	+ 0.8400	+0.10						F.
				Mean	+ 0.84010							
*0.196	P. B. M. 323	342 T. B. M.		Dir	+10.6407	+0.25	0.2	13.5	196.2951	644.019	—3.02	J.
				Rev	+10.6412	—0.25						J.
				Mean	+10.64095							
*0.196	P. B. M. 324	342 T. B. M.		Dir	+11.8590	+0.10	0.1	13.5	197.5134	648.016	—2.87	J.
				Rev	+11.8592	—0.10						J.
				Mean	+11.85910							
2.360	T. B. M. 343	342 T. B. M.	466.21	Dir	— 1.2663	—0.95	0.6	13.6	184.3855	604.945	—4.44	J.
				Rev	— 1.2682	+0.95						J.
				Mean	— 1.26725							
0.648	P. B. M. 325	343 T. B. M.		Dir	+ 0.3773	+0.45	0.3	13.6	184.7633	606.184	—4.39	J.
				Rev	+ 0.3782	—0.45						J.
				Mean	+ 0.37775							
*0.648	P. B. M. 326	343 T. B. M.		Dir	+ 1.5940	+0.65	0.4	13.6	185.9803	610.177	—4.25	J.
				Rev	+ 1.5953	—0.65						J.
				Mean	+ 1.59465							
1.845	T. B. M. 344	343 T. B. M.	468.06	Dir	+ 2.9145	+0.30	0.2	13.6	187.3006	614.509	—4.09	J.
				Rev	+ 2.9151	—0.30						J.
				Mean	+ 2.91480							
*0.105	P. B. M. 327	344 T. B. M.		Dir	+ 5.1375	0.00	0.0	13.6	192.4387	631.366	—3.48	F.
				Rev	+ 5.1375	0.00						F.
				Mean	+ 5.13750							

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0.794	T. B. M. 345	344 T. B. M	468.85	Dir	+ 0.6985	+0.55	0.4	13.6	187.9997	616.802	—4.01	J.
				Rev	+ 0.6996	—0.55						J.
				Mean	+ 0.69905							
*0.032	P. B. M. 328	345 T. B. M		Dir	— 0.8798	—0.05	0.0	13.6	187.1198	613.916	—4.11	F.
				Rev	— 0.8799	+0.05						F.
				Mean	— 0.87985							
*0.032	P. B. M. 329	345 T. B. M		Dir	+ 0.3292	—0.10	0.1	13.6	188.3289	617.883	—3.96	F.
				Rev	+ 0.3290	+0.10						F.
				Mean	+ 0.32910							
2.498	T. B. M. 346	345 T. B. M	471.85	Dir	— 2.7979	+1.90	1.8	13.6	185.2034	607.628	—4.34	F.
				Rev	— 2.7941	—1.90						F.
				Mean	— 2.79600							
*0.018	P. B. M. 330	346 T. B. M		Dir	— 1.0760	—0.10	0.1	13.6	184.1272	604.097	—4.46	F.
				Rev	— 1.0762	+0.10						F.
				Mean	— 1.07610							
*0.018	P. B. M. 331	346 T. B. M		Dir	+ 0.1453	—0.25	0.2	13.6	185.3485	608.104	—4.32	F.
				Rev	+ 0.1448	+0.25						F.
				Mean	+ 0.14505							
0.950	T. B. M. 347 and 347 *a*	346 T. B. M	472.30	Dir	+ 1.9101	—0.30	0.2	13.6	187.1134	613.895	—4.11	J.
				Rev	+ 1.9095	+0.30						J.
				Mean	+ 1.90980							
1.600	T. B. M. 348	347 T. B. M	473.90	Dir	+ 0.5153	+0.90	0.6	13.6	187.6297	615.589	—4.05	F.
				Rev	+ 0.5171	—0.90						F.
				Mean	+ 0.51620							
0.447	T. B. M. 349	348 T. B. M	474.34	1. Dir	— 0.9993	+2.12	0.5	13.6	186.6324	612.317	—4.16	F.
				1. Rev	— 0.9965	—0.68						F.
				2. Dir	— 0.9959	—1.28						J.
				2. Rev	— 0.9970	—0.18						J.
				Mean	— 0.99718							
*0.012	P. B. M. 332	349 P. B. M		Dir	— 0.8072	0.00	0.0	13.6	185.8251	609.668	—4.26	J.
				Rev	— 0.8072	0.00						J.
				Mean	— 0.80720							

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DESCRIPTIONS AND ELEVATIONS OF PRECISE BENCH MARKS BETWEEN ST. PAUL, MINNESOTA, AND SAVANNA, ILLINOIS.

[NOTE—Elevations are given in meters and feet above the Cairo datum plane. A. P. B. M. is a precise bench mark which is set with special care so as to be practically permanent. A. T. B. M. is a temporary bench mark whose elevation is as well determined as the P. B. M., but which is not regarded as specially permanent. To reduce to mean Gulf level at Biloxi, Miss., subtract 21.26 feet (preliminary value) from the elevations here given. These bench marks were established in 1891. One meter = 3.2808693 feet.]

U. S. T. B. M. 1 is in St. Paul, on the southeast corner of Washington and Eagle streets, on curbing, directly over the center of inlet grating, being the highest part of square cut in the granite.

Elevation, 224.5248 meters. 736.637 feet.

U. S. P. B. M. 65 is in St. Paul, on the southeast corner of Washington and Eagle streets, 9.2 feet from the south side of Washington, 1.0 foot above the old city storehouse which stands on the east side of Eagle, in center of a regulation tile 18 inches square and 4 inches thick, set 2¾ feet below the surface of ground, being the top of a ⅝-inch copper bolt leaded vertically.

Elevation, 223.8449 meters. 734.406 feet.

U. S. P. B. M. 66 is top of cap over iron pipe 4 inches in diameter and 4 feet long, set directly over and concentric with U. S. P. B. M. 65, and standing 16 inches above ground.

Elevation, 225.0646 meters. 738.408 feet.

U. S. P. B. M. 67 is in St. Paul, on the left bank of the Mississippi River, on the shore pier of Wabasha Street Bridge, on the northwest corner of the upper pier, 6 inches from bridge seat stone, being the top of copper bolt leaded vertically, marked "U.S." ⊙ P. B. M.

Elevation, 222.0624 meters. 728.558 feet.

U. S. P. B. M. 68 is in St. Paul, on the left bank of the Mississippi River, on lower wing wall of Kansas City and St. Paul Railway Bridge, 4.76 feet above the lower end of bridge seat course and 2.75 feet back from its front edge, being top of copper bolt leaded vertically, marked U. S. ⊙ P. B. M.

Elevation, 220.4215 meters. 723.174 feet.

Old U. S. B. M. "A" is in St. Paul, on the left bank of the Mississippi River, on the lower bench of retaining wall of embankment of the Chicago, St. Paul and Kansas City Railway Bridge, being the highest point of ring cut in top of stone marked "⊙".

Elevation, 221.6380 meters. 727.165 feet.

U. S. P. B. M. 70 is in St. Paul, about 100 feet west of Jackson street, on the north side of railroad tracks opposite the Diamond Joe Freight Depot, at the east end of retaining wall and 4 inches back of its face, being the top of copper bolt leaded in regulation tile.

Elevation, 220.8730 meters. 724.655 feet.

U. S. P. B. M. 71 is top of cap over iron pipe set over P. B. M. 70, about 14 inches above ground.

Elevation, 222.0925 meters. 728.656 feet.

U.S. P. B. M. 72 is on the St. Paul City court-house, Fifth and Wabasha streets, on the west end of doorsill of the south entrance to basement, 6 inches from either wall, being the top of a copper bolt leaded vertically, marked "U. S." P. B. M.

Elevation, 243.9006 meters. 800.206 feet.

Old U. S. B. M. 2½ of survey of 1889 is in St. Paul, on north abutment, east side, lowest step of wing wall of Chicago, St. Paul and Kansas City Bridge, about 2 inches from its face; also, about 2 inches from the second step, said to have been marked by a scratch "†", now being highest point in square cut in stone.

Elevation, 217.9797 meters. 715.163 feet.

Gauge of the Signal Service is in St. Paul, at the upper end of the St. Louis, St. Paul and Minneapolis Packet Company's dock.

Elevation of gauge, zero 214.7583 meters. 704.594 feet.

Gauge, U. S. Engineers is in St. Paul, about 50 feet above the lower end of the St. Louis, St. Paul and Minneapolis Packet Company's docks.

Elevation of gauge zero, 214.9138 meters. 705.104 feet.

U. S. P. B. M. 73 is in the east end of St. Paul, on the southeast side of the wall which is on the southeast side of Schmidt & Constanz's brewery, about 120 feet north from railroad tracks and 30 feet from the sand-rock bluff, being a copper bolt in tile set 3 feet below ground.

Elevation, 219.4865 meters. 720.107 feet.

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U. S. P. B. M. 74 is top of cap on iron pipe set over P. B. M. 73, standing about 12 inches above ground.
Elevation, 220.7060 meters. 724.108 feet.

P. B. M. 75 is 1,174 feet below the depot at Daytons Bluff, 1,890 feet below the water tank and 1½ feet west of the west fence of the Chicago, Milwaukee and St. Paul Railway, at the south end of gate, at runway leading to the railroad embankment, being top of copper bolt in tile.
Elevation, 218.9381 meters. 718.307 feet.

P. B. M. 76 is top of cap on iron pipe set over P. B. M. 75, standing about a foot above the surface.
Elevation, 220.1556 meters. 722.302 feet.

T. B. M. 8 is about 720 feet below Highwood Station, midway between tracks, on a stone monument 7 inches square, being the highest point in small square cut on top surface.
Elevation, 221.8780 meters. 727.953 feet.

T. B. M. 9 is about 3,010 feet below Highwood Station, between the Chicago, Burlington and Northern and the Chicago, Milwaukee and St. Paul tracks, on the east end of stone culvert under the Chicago, Milwaukee and St. Paul track, on coping stone, being the highest point in square.
Elevation, 218.8722 meters. 718.091 feet.

T. B. M. 10 is about 1½ miles below Highwood Station, opposite the foot of Pig Eye Lake, several hundred feet below railroad cut, at the west foot of embankment, by P. B. M. 77, on a very large, conspicuous granite bowlder, being the highest point in square.
Elevation, 222.9746 meters. 731.551 feet.

P. B. M. 77 is about 1½ miles below Highwood, opposite the foot of Pig Eye Lake, at the west fence of the Chicago, Milwaukee and St. Paul right of way on its east side, about 60 feet below the large granite bowlder carrying T. B. M. 10, being a copper bolt in tile.
Elevation, 221.3748 meters. 726.302 feet.

P. B. M. 78 is top of cap on iron pipe set over P. B. M. 77, standing 14 inches above ground.
Elevation, 222.5934 meters. 730.300 feet.

T. B. M. 11 is about 1,350 feet above the depot at Red Rock, 140 feet south of a large bowlder lying at the west foot of bank overgrown with vines, 9 feet east of the west right-of-way fence, 35 feet northeast from an oak tree 1 foot in diameter, blazed, being highest point in square cut on embedded bowlder.
Elevation, 227.4685 meters. 746.294 feet.

T. B. M. 12 is in Newport, Minn., on the southeast corner of lot belonging to and at the residence of Mr. H. A. Jones, depot agent of the Chicago, Milwaukee and St. Paul Railway, on the top of heavy iron rod driven into the ground marking his corner, on the northeast edge of rod.
Elevation, 232.8657 meters. 764.002 feet.

P. B. M. 79 is in Newport, Minn., on the northeast corner of lot belonging to and at the residence of Mr. H. A. Jones, depot agent of the Chicago, Milwaukee and St. Paul Railway, set exactly on the corner as per original gas pipe, removed, being copper bolt in tile.
Elevation, 231.6946 meters. 760.160 feet.

P. B. M. 80 is top of cap on iron pipe set over P. B. M. 79, standing about 4 inches above surface of ground.
Elevation, 232.9134 meters. 764.158 feet.

Old U. S. B. M. 12, also called old P. B. M. 3, is at Newport Landing, 80 feet above the upper warehouse, in top of ledge two-thirds of the way up the river bank, being the top of a large ring bolt, with ring.
Elevation, 217.3881 meters. 713.222 feet.

P. B. M. 81 is at St. Paul Park, at the southwest corner of Broadway and Third street, on the Syndicate Block, on the east end of doorstep, being the top of a copper bolt leaded vertically, marked "U. S." • P. B. M.
Elevation, 233.3846 meters. 765.704 feet.

T. B. M. 14 is on the street between St. Paul Park and Pullman, named Tenth avenue at its south line and 15 feet west of the right of way of the Chicago, Burlington and Northern Railway, being top of iron gas pipe.
Elevation, 235.5450 meters. 772.792 feet.

P. B. M. 83 is between St. Paul Park and Pullman, on the north side of Tenth avenue and 1½ feet east of the west right-of-way limit of the Chicago, Burlington and Northern Railway, being top of copper bolt in tile.
Elevation, 234.9214 meters. 770.746 feet.

P. B. M. 84 is top of cap on iron pipe set over P. B. M. 83, standing 1 foot above ground.
Elevation, 236.1380 meters. 774.738 feet.

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T. B. M. 17 is 1¼ miles below Pullman Station, 1,870 feet south of Tibbits Crossing in the upper part of a long rock cut, on the west side of the Chicago, Burlington and Northern track, about 2 feet above the ties, on a very hard and prominent point of ledge, being the highest point in square, marked U. S. B. M.
Elevation, 233.4363 meters. 765.874 feet.
T. B. M. 20 is at the head of Nininger Slough, at the south foot of the Chicago, Burlington and Northern embankment, just north of where P. B. M. 85 is located, being a 6-inch wire spike in oak stump.
Elevation, 219.6993 meters. 720.805 feet.
P. B. M. 85 is opposite the head of Nininger Slough, 1¼ feet north of the south line of the Chicago, Burlington and Northern right-of-way fence, about 30 feet from a blazed oak tree standing in field, facing the P. B. M., and being the top of copper bolt in tile.
Elevation, 217.6546 meters. 714.096 feet.
P. B. M. 86 is top of cap on iron pipe set over P. B. M. 85, standing 14 inches above ground.
Elevation, 218.8785 meters. 718.112 feet.
T. B. M. 22 is behind Island 18, 1,140 meters above the upper culvert at foot of Nininger Slough, several feet north of the Chicago, Burlington and Northern track, 9 feet below a small wooden box culvert under track, being the highest point in square, cut on an embedded sandstone.
Elevation, 217.4284 meters. 713.354 feet.
P. B. M. 87 is directly opposite the foot of Nininger Slough, on the west end of culvert under the Chicago, Milwaukee and St. Paul track, on the coping stone, 5.7 feet south of the center of culvert, being the top of copper bolt leaded vertically, marked "U. S."
P. B. M.
Elevation, 216.9060 meters. 711.640 feet.
Old U. S. B. M. 36 is at foot of Nininger Slough, about 60 feet from river bank, between culverts, 250 feet below the upper culvert, where P. B. M. 87 is located, and 450 feet above the Franklin Coulee Culvert, on a 14-inch elm, marked with a cross, being a spike in the north root.
Elevation, 214.1856 meters. 702.715 feet.
Old U. S. B. M. 23, also called Old P. B. M. 4, is about 700 feet below the mouth of Nininger Slough, between railroad tracks, at the Franklin Coulee Culvert, on the upper end of coping stone, being the highest point in square.
Elevation, 217.7940 meters. 714.554 feet.
T. B. M. 23 is on left bank, about 1½ miles above Hastings, Minn., at prominent point of bluff, 1,103 meters above the crossing of Chicago, Burlington and Northern and the Stillwater branch of the Chicago, Milwaukee and St. Paul, midway between tracks, being the highest point in square cut on a large sandrock, marked U. S. B. M. The same letters, but very large, are cut in the face of the sand bluff just back.
Elevation, 217.6597 meters. 714.113 feet.
P. B. M. 88 is opposite Hastings, on the line of the Chicago, Burlington and Northern Railway, 108½ feet eastward from center of track and 169¼ feet south from its crossing with the Stillwater branch of the Chicago, Milwaukee and St. Paul, just west of wire fence and north of the gate through it, leading to the house of Thomas McDermott, being top of copper bolt in tile.
Elevation, 216.9613 meters. 711.822 feet.
P. B. M. 89 is top of cap on iron pipe set over P. B. M. 88, standing 1 foot above ground.
Elevation, 218.1828 meters. 715.829 feet.
P. B. M. 96 is opposite Hastings, on the line of the Chicago, Milwaukee and St. Paul, 935 feet up the track from the draw pier of the Hastings Bridge, at Bridge No. 270, over slough, on the east end of north abutment, at the south part of curve of coping stone, being the highest point in square marked U. S.
Elevation, 216.7914 meters. 711.264 feet.
P. B. M. 97 is at Hastings, Minn., on the draw pier of the Chicago, Milwaukee and St. Paul Railway Bridge, on the upstream side top of masonry, 6 inches south of the gangway leading from draw pier to the upper breakwater crib.
Elevation, 217.9101 meters. 714.935 feet.
U. S. gauge at Hastings, Minn., above the drawbridge of the Chicago, Milwaukee and St. Paul Railway, on the southwest corner of the upper breakwater crib, being a staff gauge spiked to the timbers.
Elevation of gauge zero, 210.4230 meters. 690.370 feet.
T. B. M. 26 is 723 meters above the upper end of the Chicago, Burlington and Northern trestle at Point Douglas, on the east side of track, at the base of the rock cut, about 80 feet above the center of E. H. Whittaker's house, 178 feet above the upper end of the railroad bridge, which is midway between the houses of G. H. Campbell and E. H. Whittaker, being a square cut on ledge directly under P. B. M. 90.
Elevation, 222.1664 meters. 728.899 feet.

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P. B. M. 90 is 723 meters above the upper end of the Chicago, Burlington and Northern trestle at Point Douglas, on the east side of track, in face of rock cut, 80 feet above the center of E. H. Whittaker's house, 178 feet above the upper end of railroad bridge, which is halfway between the houses of G. H. Campbell and E. H. Whittaker, being center of copper bolt leaded horizontally, marked U. S. ⊙ P. B. M. and directly over T. B. M. 26.

Elevation, 223.2416 meters. 732.427 feet.

T. B. M. 27 is at Prescott, Wis., on the west pier of the Chicago, Burlington and Northern Bridge over the St. Croix River, on the south side of track, on top stone, being highest point in square marked U. S.

Elevation, 218.9238 meters. 718.260 feet.

P. B. M. 91 is at Prescott, Wis., on the east pier of the Chicago, Burlington and Northern Bridge over the St. Croix River, on the north end of bridge seat, being a copper bolt leaded vertically, marked "U. S." ⊙ P. B. M.

Elevation, 218.0010 meters. 715.233 feet.

T. B. M. 28 is at Prescott, Wis., at the east end of the Chicago, Burlington and Northern Bridge over the St. Croix River, on the north side of track, 2½ feet from rail, on retaining wall 1 foot east of its west end, being highest point in square.

Elevation, 219.8814 meters. 721.402 feet.

T. B. M. 30 is about 1¼ miles below the bridge across the St. Croix River at Prescott, about 15 feet eastward from center of track at foot of bank, about 133 meters below the Chicago, Burlington and Northern Bridge over Pine Coulee, and about 65 feet below milepost 24, just below P. B. M. 92, being the highest point in square cut on bowlder.

Elevation, 215.1188 meters. 705.777 feet.

P. B. M. 92 is about 1¼ miles below the bridge across the St. Croix River at Prescott, 125 meters below the Chicago, Burlington and Northern Bridge across Pine Coulee, 38 feet below milepost 24 and 5 feet west of the east wire fence of the right of way, being the top of copper bolt in tile.

Elevation, 215.6162 meters. 707.409 feet.

P. B. M. 93 is top of cap on iron pipe set over P. B. M. 92, standing 1 foot above surface.

Elevation, 216.8336 meters. 711.403 feet.

T. B. M. 32 is about 3¾ miles below Prescott, Wis., at the south end of bridge 562 of the Chicago, Burlington and Northern track, 2½ feet west from the east end of the ground sill, being top of wire spike in center of square cut in the timber.

Elevation, 215.2749 meters. 706.289 feet.

P. B. M. 94 is about 3¾ miles below Prescott, Wis., 43 feet south of the center of the Chicago, Burlington and Northern bridge 562, 46 feet east of the center of track and 53 feet westward from a blazed oak tree on the slope of bluff, being top of copper bolt in tile.

Elevation, 213.3530 meters. 699.983 feet.

P. B. M. 95 is top of cap on iron pipe set over P. B. M. 94, standing 1 foot above ground.

Elevation, 214.5715 meters. 703.981 feet.

T. B. M. 35 is opposite Smiths Bar, behind, and one-third of its length above, the lower end of small lake, 1,540 feet below milepost 28, 1,078 feet below bridge 554, 15 feet below a small wooden-box culvert, and 20 feet eastward from center of track, being the highest point in square cut on a limestone rock, marked "U. S."

Elevation, 214.5276 meters. 703.837 feet.

P. B. M. 98 is at Smiths Landing, about 10 feet above the lower end of bridge 552 and 105 feet eastward from center of track, 20 feet south from center of creek bed, and 154 feet from the southeast corner of Smith's house now occupied by George Gunter, under plum tree, being top of copper bolt in tile.

Elevation, 213.6359 meters. 700.911 feet.

P. B. M. 99 is top of cap on iron pipe set over P. B. M. 98, standing 1 foot above ground.

Elevation, 214.8546 meters. 704.910 feet.

T. B. M. 37 is at Smiths Landing opposite the extreme lower end of bridge 552, Chicago, Burlington and Northern, at the east foot of embankment by a blazed post, on a round imbedded bowlder, being the highest point in square cut in stone.

Elevation, 213.2649 meters. 699.694 feet.

T. B. M. 38 is 1,000 meters below Smiths Landing, 124 meters above milepost 30, from St. Paul, 45 feet above bridge 549, 37 feet from center of track on bank of river, on a large blue sandstone, being the highest point in square.

Elevation, 214.4557 meters. 703.601 feet.

T. B. M. 39 is 490 meters below Morgans Coulee, 124.6 meters below milepost 31, on

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the east side of railroad, on an imbedded rock in the slope of a cut, being the highest point in square.

Elevation, 215.7807 meters. 707.948 feet.

Recent U. S. B. M. (probably the same as old U. S. B. M. 15), is 2¼ miles above Diamond Bluff, on an island, on the top edge of river bank, one-half mile below Morgans Coulee, 240 meters below the dike across chute running behind this island, on a 3-foot elm tree carrying a large blaze, being a large spike in west root.

Elevation, 212.9836 meters. 698.771 feet.

T. B. M. 40 is 93 meters below Chicago, Burlington and Northern Bridge 544, on the north side of track at foot of bluff, 8 feet from center of track, opposite a blazed tree, on a rock, being the highest point in square.

Elevation, 218.1218 meters. 715.629 feet.

T. B. M. 47 is three-fourths of a mile above Diamond Bluff, on land of Ed. Colter, 213 meters south from center of bridge over Wind or Spring Creek, about at the elevation of extreme high water, at foot of bank, about 25 meters southward from the end of small road bridge over run, and about 40 meters from river, at a medium stage of water; on a large imbedded granite bowlder, being the highest point in square, marked "U. S."

Elevation, 213.2608 meters. 699.681 feet.

P. B. M. 100 is three-fourths of a mile above Diamond Bluff, on land of Ed. Colter, 7 meters northward from T. B. M. 47, on point of bank, about 600 feet below Wind or Spring Creek, 62 feet southward from center of the small road bridge and 21 feet nearer the river; 22½ feet northwest from a 4-inch oak tree blazed, being copper bolt in tile.

Elevation, 214.6350 meters. 704.189 feet.

P. B. M. 101 is top of cap on iron pipe set over P. B. M. 100, 1 foot above ground.

Elevation, 215.8519 meters. 708.182 feet.

T. B. M. 45 is in Diamond Bluff, 70 meters below the Chicago, Burlington and Northern station and 19 meters northward from center of track, 3 feet south of wire fence, on a large bowlder, being the highest point in square.

Elevation, 226.5561 meters. 743.301 feet.

P. B. M. 102 is in Diamond Bluff, 70 meters east of the Chicago, Burlington and Northern station, 14 meters southward from main track and 2 meters north of the wire fence, being top of bolt in tile.

Elevation, 226.3466 meters. 742.614 feet,

P. B. M. 103 is top of cap on iron pipe set over P. B. M. 102, standing 1 foot above ground.

Elevation, 227.5625 meters. 746.603 feet.

T. B. M. 46 is three-fourths of a mile below Diamond Bluff, 37 feet south from center of track, 94 meters below the east end of bridge 536, over Dry Run, on the large bowlder in borrow pit, being the highest point in square marked "U. S." ⊓ T. B. M.

Elevation, 227.1901 meters. 745.381 feet.

P. B. M. 104 is three-fourths of a mile below Diamond Bluff, Wisconsin, 29 meters south of center of track and 90 meters below the east end of Bridge 536, over Dry Run, 2 meters northward from blazed post in wire fence, at foot of bank in borrow pit, copper bolt in tile.

Elevation, 225.6889 meters. 740.456 feet.

P. B. M. 105 is top of cap on iron pipe set over P. B. M. 104, standing about 14 inches above ground.

Elevation, 226.9112 meters. 744.466 feet.

T. B. M. 48 is about 2¼ miles below Diamond Bluff, 700 feet above Neros Crossing, 400 feet above Gardner Skidmore's house, 12 feet north from center of Chicago, Burlington and Northern track, on the slanting face of ledge of rock, being the highest point in square, marked "U. □ S."

Elevation, 226.4043 meters. 742.803 feet.

T. B. M. 49 is about a mile above Trenton, in center of wagon road leading to Diamond Bluff, about one-half mile southward from its crossing with the Chicago, Burlington and Northern track, below and 65 meters from H. L. Curry's house, on root of oak tree 1 foot in diameter, being a large wire spike.

Elevation, 222.1563 meters. 728.866 feet.

T. B. M. 50 is at Trenton, Wis., on top of bluff, about 100 feet back from edge of descent, and 45 feet east of old storehouse, in an oak tree 10 inches in diameter, being a 6-inch wire spike in west root of tree.

Elevation, 239.2933 meters. 785.090 feet.

T. B. M. 51 is at Trenton Landing, about 70 feet south of road, 65 feet back from line of willows, on top of bank, on the south root of a large elm tree 30 inches in diameter, blazed, marked "U," being top of a 6-inch wire spike.

Elevation, 212.0971 meters. 695.863 feet.

P. B. M. 106 is at Trenton Landing, Wisconsin, about 30 feet below T. B. M. 51, 3½ feet toward the river from a tree blazed, being a copper bolt in tile.

Elevation, 211.7737 meters. 694.802 feet.

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P. B. M. 107 is top of cap on iron pipe set over P. B. M. 106, standing about 14 inches above ground.
Elevation, 212.9971 meters. 698.816 feet.
T. B. M. 52 is on the left bank of chute opposite the head of Island 24, 300 meters below the north end of pile dike, 6 feet back from top of bank, in the center between three cottonwood trees blazed, and 7 feet from all, on a 14-inch new cottonwood stump, being top of 6-inch wire spike.
Elevation, 212.5419 meters. 697.322 feet.
T. B. M. 53 is on the extreme upper end of Island 24, 2 miles above Pucketville, about 75 feet eastward from the river bank, on a 4-foot elm stump, being a 6-inch wire spike.
Elevation, 212.4390 meters. 696.985 feet.
P. B. M. 108 is about 55 feet southward from T. B. M. 53, 2 miles above Pucketville, at the center of the head of Island 24, on the highest ground, about 125 feet from the river and 100 feet from the chute, 2 maple trees near by are blazed facing the P. B. M., being top of copper bolt in tile.
Elevation, 211.6172 meters. 694.288 feet.
P. B. M. 109 is top of cap on iron pipe set over P. B. M. 108, standing 1 foot above ground.
Elevation, 212.8337 meters. 698.280 feet.
T. B. M. 56 is in Pucketville, about 200 feet below the ferry landing, just behind retaining wall at the river front in Mr. Truttman's yard, 10.5 feet southeast from P. B. M. 111, in root of large cottonwood tree, being a 6-inch spike.
Elevation, 212.4488 meters. 697.017 feet.
P. B. M. 110 is on Island 24, opposite Red Wing, in Pucketville, 200 feet below the ferry landing, in the front part of Mr. Truttman's yard, 12 feet back from the front angle of retaining wall, 10½ feet northwest from the large cottonwood tree carrying T. B. M. 56, 3.7 feet eastward from a 12-inch maple, 21 feet from the southwest corner of Mr. Truttman's house, being top of copper bolt in tile.
Elevation, 211.4532 meters. 693.750 feet.
P. B. M. 111 is top of cap on iron pipe set over P. B. M. 110, standing 1 foot above ground.
Elevation, 212.6630 meters. 697.720 feet.
P. B. M. 112 is in Red Wing, Minn., on the southwest corner of Plum and Levee streets, in the northeast corner of the La Grange Mill, in the east face of the foundation wall, 2.3 feet south from the north face and 2.1 feet above the sidewalk, being the center mark in copper bolt leaded horizontally, marked "U. S." P. B. M.
Elevation, 215.8417 meters. 708.148 feet.
P. B. M. 113 is at Red Wing, about 1,300 feet below the Chicago, Milwaukee and St. Paul depot, at the base and upper end of Barn Bluff, on the lower abutment, river side of small railroad bridge, on the first step below the top, 6 inches from the first step, being top of copper bolt leaded vertically, and marked "U. S." ⊙ P. B. M.
Elevation, 212.6560 meters. 697.697 feet.
Gauge is in Red Wing, at the Diamond Joe warehouse, on the downstream face of recess in crib work, being a staff gauge, spiked to timbers.
Elevation of its zero 208.9846 meters. 685.651 feet.
T. B. M. 57 is ¾ of a mile below the small railroad bridge at the upper end of Barn Bluff, at the foot of Barn Bluff, about 45 feet east from the northeast corner of the Pioneer Lime Works, on the top stone of wall retaining the wagon road, being the highest point in square, marked "U. □ S."
Elevation, 215.8369 meters. 708.133 feet.
T. B. M. 58 is 1¾ miles below Red Wing, between the two road crossings, about 328 feet above the slaughterhouse, 6½ feet northward from center of track, opposite a crossing signal board; 810 feet above P. B. M. 215, being the highest point in a square, on an embedded rock.
Elevation, 221.8833 meters. 727.970 feet.
P. B. M. 114 is nearly 2 miles below Red Wing, at a wagon-road crossing, 5 feet below its east fence and 20 feet northward from center of track, ½ of a mile above the slaughterhouse, being copper bolt in tile.
Elevation, 218.6565 meters. 717.383 feet.
P. B. M. 115 is top of cap on iron pipe set over P. B. M. 114, standing a foot above ground.
Elevation, 219.8717 meters. 721.370 feet.
T. B. M. 59 is on the right bank about 2⅜ miles below Red Wing, opposite the head of Island 26, in front of the Minnesota Reform School Building, on a large triangular sandstone, about 10 feet southwest of a blazed elm tree and 20 feet from shore, at a medium stage, marked "U. □ S."
Elevation, 211.0708 meters. 692.496 feet.

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T. B. M. 60 is on the right bank, about 3 miles below Red Wing, Minn., 492 feet below the foot of Island 26, 39 feet from low-water shore at foot of bluffs, 2 feet above a very large and conspicuous white rock, on a large embedded bowlder, being the highest point in square, marked "U. □ S."

Elevation, 211.0983 meters. 692.586 feet.

T. B. M. 61 is about 3⅜ miles below Red Wing, and ⅝ mile above the head of Island 28, just above a little tow-head and 180 feet above a large lone elm tree near shore at a medium low stage, on a very large piece of rock, being highest point in square marked "U. □ S."

Elevation, 210.7992 meters. 691.605 feet.

Old U. S. B. M. 32 is about ⅜ of a mile above the head of Island 28, at the lower side of a wide flat point built up from the wash of the creek coming out from between bluffs 820 feet above, about 25 feet back from low-water shore, 100 feet below fishermen's shanties, on nail in the east root of a large lone elm tree.

Elevation, 210.8487 meters. 691.767 feet.

P. B. M. 116 is 1¾ miles above Wacouta and 1,722 feet above the head of South Channel, at the east foot of the round point of bluff on the lower side of creek, above fishermen's shanties above old B. M. 32, 15 feet west from a 6-inch blazed ash marked U. S., 31 feet north from another blazed ash and 20 feet east from a blazed oak tree, being a copper bolt in tile.

Elevation, 212.3170 meters. 696.584 feet.

P. B. M. 117 is top of cap on iron pipe set over P. B. M. 116 standing a foot above surface of ground.

Elevation, 213.5334 meters. 700.575 feet.

Old U. S. B. M. ? is about 3,445 feet above the mouth of Ida Creek, on a prominent point of the right bank of South Channel, at foot of bluff, on the center one of three large cottonwood trees on the river bank, being a spike in the downstream root.

Elevation, 211.2920 meters. 693.221 feet.

Old U. S. B. M. 33 is at Wacouta, on the right bank of South Channel, at river bank, about 30 feet from low-water line at foot of bluff, 1,230 feet above Ida Creek, on a cottonwood tree 40 inches in diameter, being a nail in root facing the river.

Elevation, 211.0924 meters. 692.567 feet.

T. B. M. 62 is at Wacouta, east of Ida Creek, at the point of steep sand bluff 18¼ feet south from wire fence, about 3 inches below the surface of the ground, on a fine large lone elm tree, being a 6-inch wire spike in its west root.

Elevation, 213.0210 meters. 698.894 feet.

P. B. M. 118 is at Wacouta, below Ida Creek at the point of steep sand bluff, close to the south side of wire fence, 17¼ feet above the large elm, in which is located T. B. M. 62, being copper bolt in tile.

Elevation, 212.2801 meters. 696.463 feet.

P. B. M. 119 is top of cap on iron pipe set over P. B. M. 118, standing about 1 foot above the surface of the ground.

Elevation, 213.4993 meters. 700.463 feet.

T. B. M. 63 is at the mouth of South Channel, about 1,476 feet below the mouth of Ida Creek, at the foot of sand bluff, at about high-water elevation, on the north root of a large lone cottonwood tree, being a spike driven to the same elevation as old U. S. B. M. 34? The old nail was rotted loose.

Elevation, 211.8942 meters. 695.197 feet.

T. B. M. 64 is on the right bank of Lake Pepin, about 1⅛ miles below the mouth of Ida Creek, on the third point from the upper end of the lake, on the west side of the point of woods, at about high-water elevation, in the root of a 10-inch ash tree broken off about 5 feet above ground; on the same stump and approximately the same elevation as old U. S. B. M. 36, which was rotted out (≐ tack.) Head of a 6-inch wire spike.

Elevation, 212.0592 meters. 695.738 feet.

T. B. M. 65 is on the right bank of Lake Pepin, about 2⅜ miles below Ida Creek and 3¾ miles above Lake Side, on the first wide wooded point, on the upper side of the point, about 450 feet from end of point at a medium low stage, on the root of a 14-inch oak blazed and marked U. S., being the top of the spike.

Elevation, 212.1654 meters. 696.087 feet.

P. B. M. 120 is on Lake Pepin, about 3¾ miles above Lake Side, on the wide flat wooded sand point, on the first point below the U. S. Light, about 125 feet southeast of T. B. M. 65, about in center of the point east and west, 230 feet from the end of the point at a medium low stage, 262 feet west, 10° north from the east shore and 193 feet southeast from the northwest shore line, being copper bolt in tile, trees blazed.

Elevation, 211.7456 meters. 694.710 feet.

P. B. M. 121 is top of cap on iron pipe set over P. B. M. 120, about 1 foot above ground.

Elevation, 212.9653 meters. 698.711 feet.

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T. B. M. 66 is on the right bank of Lake Pepin, about 3,280 feet below the wide flat wooded sand point, which is about 3¾ miles above Lake Side, 295 feet below the exceedingly large rock, under a 6-inch ash tree blazed, on an embedded bowlder about the middle of the beach, being highest point in square, marked "U. □ S."

Elevation, 211.0737 meters. 692.505 feet.

T. B. M. 67 is on the right bank of Lake Pepin, about 2¾ miles above Lake Side, and 1½ miles below the wide flat sand point at the south end of a long stretch of straight shore 25 feet below two exceedingly large rocks in the middle of the way, 20 feet from a linn tree blazed, on an embedded bowlder, being the highest point in square, marked "U. □ S."

Elevation, 210.8417 meters. 691.744 feet.

T. B. M. 69 is on right bank of Lake Pepin, 1½ miles above Lake Side, 3,600 feet above Point no Point, in the middle of the way, 28 feet from foot of bluff and 49 feet east from a blazed elm (top of tree broken off) on the east end of an embedded bowlder, being the highest point in square, marked "U. □ S."

Elevation, 210.4633 meters. 690.503 feet.

T. B. M. 70 is on Point no Point, Lake Pepin, being the last point in view from Lake Side looking up the lake, 60 feet below a very large round prominent bowlder standing out in lake, 28 feet from foot of bluff, near the shore in the way, easily seen, on a large flat rock well embedded, with its upper face inclining about 25 degrees with the northeast horizon, being a square, marked "U. □ S."

Elevation, 210.0853 meters. 689.262 feet.

T. B. M. 72 is on Lake Pepin, at Lake Side Hotel, Lake Side, 45 feet southwest from the driven well on the point, 5 feet west from path leading to well, in root of an oak tree, being a 6-inch wire spike.

Elevation 212.8844 meters. 698.446 feet.

P. B. M. 122 is on Lake Pepin, at Lake Side, at the Lake Side Hotel, 50 feet southward from the driven well on the point, 7 feet east of path leading to well, 13 feet eastward from the oak tree bearing T. B. M. 72, being copper bolt in tile about 3 feet underground.

Elevation 211.8762 meters. 695.138 feet.

P. B. M. 123 is top of cap on iron pipe set over P. B. M. 122, standing about 1 foot above ground.

Elevation 213.0920 meters. 699.127 feet.

T. B. M. 73 is on Lake Pepin, 2,506 feet below the Lake Side Hotel, at Lake Side, at the west point of woods, on the north side of wagon road, about 328 feet below the fisherman's house, on a 33-inch oak tree, being a 6-inch wire spike in its south root.

Elevation 212.4603 meters. 697.054 feet.

T. B. M. 74 is on Lake Pepin, 1½ miles below Lake Side Hotel, at Lake Side, about a half mile back, west from the lake shore, at fork of roads in front of convent, 36 feet west from the main road and 25 feet south from end of culvert under road leading to convent, on a 2-foot oak tree, being a nail in root.

Elevation 220.0968 meters. 722.109 feet.

T. B. M. 75 is on Lake Pepin, about 2¼ miles below Lake Side Hotel, and 1¼ miles below Mells Creek, 656 feet above Henry Whipples house, 150 feet back west from bank of slough, and 35 feet from road towards lake, about 30 inches from the north side of a 20-inch oak tree, being a 6-inch wire spike in its root.

Elevation 216.2986 meters. 709.647 feet.

T. B. M. 76 is on Lake Pepin, at Florence, at the southeast corner of A. M. C. Johnson's dooryard, at the northwest corner of intersecting roads, about 197 feet back from river bank, on base stone of iron fence, 2.1 feet north from the corner, being the highest point in square, marked "U. □ S."

Elevation 215.0808 meters. 705.652 feet.

P. B. M. 124 is on Lake Pepin, in Florence, on the northwest corner of the same streets as T. B. M. 76, 134 feet north from the corner, which is the southeast corner of Mr. A. M. C. Johnson's yard, on the west side of wagon road, 6 inches back of the face line produced, of iron fence, being a copper bolt in tile about 3 feet below surface.

Elevation 213.3152 meters. 699.859 feet.

P. B. M. 125 is top of cap on iron pipe set over P. B. M. 124, standing about a foot above ground.

Elevation 214.5347 meters. 703.860 feet.

T. B. M. 77 is on Lake Pepin, 3,363 feet below Florence, on the beach, 60 feet from foot of high bank, on a large, prominent, black granite bowlder, easy to find, being the highest point in square, marked U. S.

Elevation 211.1572 meters. 692.779 feet.

T. B. M. 78 is on Lake Pepin, 1½ miles below Florence, on beach, at the upper end of clearing, 75 feet below the upper end of very large ice house, on the north root of a large, lone ash tree, being top of a 6-inch wire spike in its root.

Elevation 211.2009 meters. 692.922 feet.

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T. B. M. 79 is on Lake Pepin, about 2 miles below Florence, on the south side of the first large flat sand point above Central Point, on the east side of wood road, on an oak tree blazed and marked "U" being a 6-inch wire spike in its root.

Elevation 212.5264 meters. 697.271 feet.

T. B. M. 80 is on Lake Pepin, in the village of Central Point, about 1⅝ miles above Lake City, and 131 feet above the sawmill, on the west side of road leading to the island, on the south root of a 14-inch ash tree blazed, being a 6-inch wire spike.

Elevation 212.1965 meters. 696.189 feet.

P. B. M. 126 is on Lake Pepin, in the village of Central Point, on the east boundary line of Front street, 66 feet from the fence, on the west side of Front street, 152 feet northward from the northwest corner of Main and Front streets, 92 feet from the southeast corner of the sawmill office, 240 feet southeast from the property corner of Geo. H. Grannis and F. A. Coon, and 95 feet from the southwest corner of saw mill, being copper bolt in tile.

Elevation 212.0951 meters. 695.856 feet.

P. B. M. 127 is top of cap on iron pipe set over P. B. M. 126, standing about 8 inches above the surface of ground.

Elevation 213.3100 meters. 699.842 feet.

T. B. M. 81 is on Lake Pepin, at the upper end of Lake City, at the east end of long straight beach, and at the beginning of curved beach, ⅞ miles below creek, in Central Point Village, ⅝ of a mile above Center street, 25 feet eastward from foot of bank, on the south root of a large, lone cottonwood tree, being the top of a 6-inch wire spike.

Elevation 212.0651 meters. 695.758 feet.

P. B. M. 128 is on Lake Pepin, in Lake City, on the west side of Front street, between Lyon avenue and Center street, on T. W. Palmer's shoe store, in the north end of the window seat, being top of a copper bolt leaded vertically, marked U.S. ⊙ P. B. M.

Elevation 216.3822 meters. 709.922 feet.

P. B. M. 129 is on Lake Pepin, in Lake City, on the southeast corner of Front and Center streets, on the Merchants' Bank Building, in east end of stone doorstep, being a copper bolt leaded vertically, and marked U.S. ⊙ P. B. M.

Elevation 216.4103 meters. 710.014 feet.

Old U. S. B. M. is in Lake City, on the Diamond Joe Elevator, 10.5 feet west of the southeast corner, on the foundation stone, at the west end of stone pier, in the southeast quarter of old cross.

Elevation 211.9576 meters. 695.405 feet.

T. B. M. 82 is on Lake Pepin, about 2950 feet below Lake City Landing, 50 feet from the lake, on the line between the beach and the grass land, about 656 feet above John Berkey's summer resort, and about 263 feet below a frame house on the opposite side of the road, being a spike in the southeast root of a large oak tree.

Elevation 212.5835 meters. 697.459 feet.

P. B. M. 130 is on Lake Pepin, 2 miles below Lake City, ½ mile above the first high bluff, 105 feet below bridge 156, on the Chicago, Milwaukee and St Paul right of way, at the east fence, 115 feet from the top of the lake bank, at the upper end of cut, being a copper bolt in tile.

Elevation 217.1185 meters. 712.337 feet.

P. B. M. 131 is top of cap on iron pipe set over P. B. M. 130, standing about a foot above ground.

Elevation 218.3396 meters. 716.344 feet.

T. B. M. 84 is 3 miles below Center street of Lake City, on Lake Pepin, 9 feet towards the bluff from the center of the Chicago, Milwaukee and St. Paul Railway, 3,000 feet below bridge 154, opposite a blazed telegraph pole, on an embedded rock in the side of bank, projecting 1 foot above the surface, being highest point in square.

Elevation 214.7652 meters. 704.617 feet.

T. B. M. 86 is on Lake Pepin, at Kepler's Coulee, 1½ miles above King's Coulee Station, at the upper side of the point of land north of the railroad, covered with very large rocks, at the upper end of a very large bowlder supporting the railroad embankment, 15 feet from center of track and 25 feet from lake, being the highest point in square, marked U.S. □ T. B. M.

Elevation 213.4112 meters. 700.174 feet.

P. B. M. 132 is on Lake Pepin, at Kepler's Coulee, 1½ miles above King's Coulee station, on the north sloping face of the exceedingly large bowlder on which T. B. M. 86 is cut, being the top of a copper bolt leaded vertically and marked U.S. ⊙ P. B. M.

Elevation 213.6813 meters. 701.060 feet.

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T. B. M. 87 is on Lake Pepin, at King's Coulee, on the Chicago, Milwaukee, and St. Paul Railway bridge No. 146, on the north end of the west abutment, on the front edge of the second top stone from north end, being the highest point in square, marked "U. S."

Elevation 213.5918 meters. 700.767 feet.

P. B. M. 133 is on Lake Pepin, 150 feet below the section house, 49 feet south from center of track, 82 feet below the center of bridge 146, on the right of way at south fence, 7 feet east of the east gate post of gate across road leading through to Smith's land, being a copper bolt in tile.

Elevation 214.3041 meters. 703.104 feet.

P. B. M. 134 is top of cap on iron pipe set over P. B. M. 133, standing a foot above ground.

Elevation 215.5265 meters. 707.114 feet.

T. B. M. 88 is on Lake Pepin, at Dutchman's Coulee, 1 mile below King's Coulee station, 853 feet below bridge 142, at the upper end of a small cut, 15 feet towards lake from center of track, on a large round embedded bowlder supporting the embankment, being the highest point in square, marked "U. □ S."

Elevation 213.1864 meters. 699.437 feet.

T. B. M. 89 is on Lake Pepin, 1¾ miles below King's Coulee, 275 feet above bridge 140, on the lake side of track, at the lower end of cut, 200 feet above Copeland's Coulee Bridge, just above Theodore Halm's house, on an embedded bowlder, being the highest point in square, marked "U. □ S."

Elevation 214.6164 meters. 704.128 feet.

T. B. M. 90 is on Lake Pepin, 1¼ miles above Reeds Landing, at Eli Roscoe's Coulee, on the south side of track, on the base stone of the east retaining wall in bed of creek, being the highest point in square, marked "U. □ S."

Elevation 213.8524 meters. 701.622 feet.

P. B. M. 135 is on Lake Pepin, 1¼ miles above Reeds Landing, at Eli Roscoe's Coulee, in the point of hill between the wagon road and railroad opposite John Sandburn's house, 31 feet south from center of track, 16 feet east from the east bank of creek where T. B. M. 90 is located, and 20 feet north from the north side of road bridge, being a copper bolt in tile 3 feet under ground.

Elevation 215.0108 meters. 705.422 feet.

P. B. M. 136 is top of cap on iron pipe set over P. B. M. 135, standing a foot above ground.

Elevation 216.2294 meters. 709.420 feet.

T. B. M. 91 is at the foot of Lake Pepin, ¾ miles below Roscoe's Coulee, on prominent point of south shore, at the north side of the north railroad ditch, 9 feet from center of track, on large embedded rock, 810 feet above bridge 134, being the highest point in square, marked "U. □ S."

Elevation 214.6653 meters. 704.289 feet.

P. B. M. 137 is at Reeds Landing, 246 feet below Knapp, Stout & Co.'s warehouse, on the south side of Water street, in the north door of S. Trautmann's store, in the south end of the stone doorstep, being a copper bolt leaded vertically, marked "U. S." ⊙ P. B. M.

Elevation 215.2843 meters. 706.320 feet.

T. B. M. 93 is at Reeds Landing, 3170 feet below the Chicago, Milwaukee and St. Paul depot, 45 feet below the intersection of the said railroad with the tangent produced of the Chicago, Milwaukee and St. Paul pontoon bridge over the Mississippi River, 10 feet northward from center of track, on an embedded rock, being the highest point in square.

Elevation 214.4886 meters. 703.709 feet.

Old U. S. B. M. "A" is at Reeds Landing, just above the pontoon bridge across the Mississippi, at the northwest corner of Arthur Dunn's residence, which is on the south side of street facing the river, being the bottom of the corner strip.

Elevation, 216.5123 meters. 710.349 feet.

P. B. M. 138 is at Reeds Landing, 58 feet east from the intersection of the south fence of Water street with the tangent produced of the pontoon bridge, in the northeast corner of Arthur Dunn's lot, 8 feet south from the front fence, and 1.6 feet west of the east fence, being copper bolt in tile, 3 feet under ground.

Elevation, 215.0240 meters. 705.466 feet.

P. B. M. 139 is top of cap on iron pipe set over P. B. M. 138.

Elevation, 216.2398 meters. 709.455 feet.

T. B. M. 94 is 5,000 feet below the pontoon bridge at Reeds Landing, and 3,025 feet above the Chicago, Milwaukee and St. Paul depot at Wabasha, at the south limit of right of way between road crossings, in wild cherry tree at board fence, being a 6-inch spike in root.

Elevation, 221.8726 meters. 727.935 feet.

T. B. M. 95 is at Wabasha, Minn., on Fourth street, at the wagon bridge over the

Zumbro Slough, on the south side of west approach, 2 feet outside of sidewalk, 2,723 feet west of center of bridge on a 30-inch cottonwood tree, being a 6-inch spike in root.

Elevation, 211.8452 meters. 695.036 feet.

P. B. M. 140 is in Wabasha, on the northwest corner of Pembroke and Main streets, on The Peoples' Bank, near the north post of door of corner entrance, directly under the brick line on the south side of the south window, in water table, being a copper bolt leaded vertically, marked U. S. ⊙ P. B. M.

Elevation, 216.6593 meters. 710.831 feet.

Old U. S. B. M. 62½ is in Wabasha, at the elevator, between tracks on the north face of retaining wall and 3 feet above the corner of the wall, on the west side of runway under track to elevator, on the front part of top surface of lower corner of stone, marked "B. M."

Elevation, 212.6500 meters. 697.677 feet.

Old U. S. B. M. "E" is in Wabasha, on the old Commercial Hotel, on the southeast corner of Main and Bailey streets, on the north front of the hotel, on the upstream end of stone doorsill between two doors, 3½ inches out from the brick wall.

Elevation, 216.6225 meters. 710.710 feet.

River gauge is at Wabasha, just above the ferry landing, a small staff gauge nailed to the south side of piling

Elevation of gauge zero, 208.4931 meters. 684.039 feet.

T. B. M. 96 is in the lower part of Wabasha, in Campbells Addition, in the northwest corner of Mrs. E. J. Dugan's lot, 13 feet south from the river street fence, on a soft maple tree 2 feet in diameter, in its northwest root, being a 6-inch wire spike.

Elevation, 213.9506 meters. 701.944 feet.

P. B. M. 141 is in the lower part of Wabasha, in Campbells Addition, in the northwest corner of Mrs. E. J. Dugan's lot just above T. B. M. 96, 1.2 feet from the west fence and 1.6 feet south from the street fence, being a copper bolt in tile, 3 feet under ground.

Elevation, 212.9471 meters. 698.652 feet.

P. B. M. 142 is top of cap on iron pipe set over P. B. M. 141.

Elevation, 214.1576 meters. 702.623 feet.

T. B. M. 98 is 1½ miles below Wabasha, 275 feet below the closing dam of Crats Island Chute, 79 feet back from the water's edge at a medium low stage, on an 18-inch willow tree, being a spike in its north root.

Elevation, 209.7956 meters. 688.312 feet.

Old U. S. B. M. 66 is about 1½ miles below Wabasha, 245 feet below the closing dam of Crats Island Chute, and about 50 feet back from top of bank, but a few feet from T. B. M. 98, being a nail in root of the large lone elm tree, now loose.

Elevation, 209.9965 meters. 688.971 feet.

Old U. S. B. M. "O" is on Teepeeota Point, 16 feet from the northeast corner of David Pugh's house, being a spike in the base of an 18-inch cottonwood.

Elevation, 214.3150 meters. 703.140 feet.

P. B. M. 143 is on Teepeeota Point, in the northeast corner of David Pugh's yard, 1½ feet from the east fence, and 22 feet south from corner of fence, 102 feet from the northeast corner of the house and 89 feet from river, being a copper bolt in tile.

Elevation, 211.3133 meters. 693.291 feet.

P. B. M. 144 is top of cap on iron pipe set over P. B. M. 143.

Elevation, 212.5273 meters. 697.274 feet.

Old U. S. B. M. "N" is on Teepeeota Point, 600 feet downstream from David Pugh's house, in an 18-inch burr-oak stump, 6 feet below top of bank, being a spike driven in the base of the stump.

Elevation, 212.7451 meters. 697.989 feet.

T. B. M. 99 is on right bank, 3½ miles above Alma, Wis., and seven-eighths of a mile below Teepeeota Point, on top of sand bluff in Mr. Fedder's barnyard, being a spike in the root of an 18-inch oak tree, the only tree in lot.

Elevation, 216.5470 meters. 710.462 feet.

T. B. M. 100 is on the right bank, midway between Alma and Teepeeota Point, on top of sand bluff directly back from the shear log boom, about 262 feet above Mr. E. S. Churchill's house, on the west side of road, on an oak tree 7 inches in diameter, being 6-inch spike in root.

Elevation, 219.0216 meters. 718.581 feet.

T. B. M. 101 is on the right bank, about 2 miles above Alma, 984 feet above the log boom, and 328 feet above where the shear boom intersects the right bank, on the same ridge at river bank on a large conspicuous cottonwood tree, blazed, being a 6-inch wire spike.

Elevation, 209.2477 meters. 686.514 feet.

T. B. M. 102 is on the main right bank, about 1½ miles above Alma, 15 feet above

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the closing dike behind Island 36, and 60 feet back from river bank, and about 20 feet above P. B. M. 146, in a 30-inch elm tree, blazed, and marked U, being a 6-inch wire spike in the west root.

Elevation, 209.1672 meters. 686.250 feet.

P. B. M. 145 is on the right bank, 1½ miles above Alma, at the lower line of dike closing chute behind Island 36, about 20 feet east of T. B. M. 102, and 60 feet back from river bank, midway between elm tree and elm stub, both blazed toward the P. B. M., being top of copper bolt leaded in tile and set 3 feet below surface of ground.

Elevation, 208.5102 meters. 684.095 feet.

P. B. M. 146 is top of cap on iron pipe set over P. B. M. 145.

Elevation, 209.7272 meters. 688.088 feet.

T. B. M. 103 is on the foot of Island 39, opposite the upper end of Alma, at the lower end of willows, 50 feet back (southwest) from the bank, 25 feet above a cluster of piles, on a new willow stump 5 inches in diameter, a 6-inch wire spike.

Elevation, 208.5822 meters. 684.331 feet.

T. B. M. 104 is in the upper end of Alma, 30 feet toward river from center of track of the Chicago, Burlington and Northern Railway, on foundation of water tank on the northeast corner of the northwest pier, opposite Aultman Taylor's machine warehouse, being the highest point in square marked "U. □ S."

Elevation 211.6034 meters. 694.243 feet.

P. B. M. 147 is in the upper end of Alma., Wis., on the foundation of the Chicago, Burlington and Northern water tank, at the same tank as T. B. M. 104 in the south part of the southeast stone base, being top of copper bolt leaded vertically, marked "U. S." ⊙ P. B. M.

Elevation, 211.6044 meters. 694.246 feet.

Old U. S. B. M. "1" is at Alma, Wis., on the river front of John Harry's brick store, near the downstream end of stone window base, being highest point in circle cut in stone, "⊙."

Elevation, 213.5602 meters. 700.663 feet.

Old U. S. B. M. "3" is at Alma, Wis., on the west side of the main street, in the front of Mr. Fritsche's brick store, on the downstream window sill, being a circle cut in stone, "⊙."

Elevation, 214.1562 meters. 702.619 feet.

P. B. M. 148 is at Alma, Wis., on the east side of main street in water table of Commercial hotel, at the south side of entrance, 6 inches below the iron column, being top of copper bolt leaded vertically, marked "U. S." ⊙ P. B. M.

Elevation, 215.6781 meters. 707.612 feet.

Old U. S. B. M. "4" is in the lower end of Alma, opposite the "Sawmill and Lumber" office, 60 feet above small road bridge on the east side of street, at the entrance to F. Lane's residence, being the highest point in square.

Elevation, 213.4286 meters. 700.231 feet.

T. B. M. 105 is three-fourths of a mile below Alma sawmill, 49 feet below milepost 81, 35 feet below C. Moser's red barn, in a large imbedded rock forming the north bank of north railroad ditch, being highest point in square, marked "U. □ S.'

Elevation, 212.8926 meters. 698.473 feet.

P. B. M. 149 is three-fourths of a mile below Alma sawmill, at the east fence on the right of way of the Chicago, Burlington and Northern Railway, by milepost 81, in front of C. Moser's house, 16 feet below gate for farm crossing, being copper bolt leaded in tile, 3 feet below surface of ground, same place as T. B. M. 105.

Elevation, 212.1178 meters. 695.931 feet.

P. B. M. 150 is top of cap on iron pipe set over P. B. M. 149, about a foot above ground.

Elevation 213.3299 meters. 699.908 feet.

T. B. M. 107 is 2 miles below Alma sawmill, in the highway, about 8 feet west of the east road fence and 60 feet above the small white house at the east roadside, 13 feet northwest of the northwest corner of Anton Loetsche's yard, being the highest point in square, on imbedded rock, marked "U. □ S."

Elevation, 211.5690 meters. 694.130 feet.

T. B. M. 108 is 2¼ miles below Alma sawmill, and 620 feet below Bridge 445, at the south point of woods on the west side of track, 55 feet from center; also, 500 feet above the large barn east of the track, having a stone foundation and basement; in base of a 16-inch oak tree, at surface of ground, being the highest point of a 6-inch wire spike bent over.

Elevation, 210.0556 meters. 689.165 feet.

P. B. M. 151 is about 2¼ miles below Alma sawmill, 984 feet below Bridge 445, and 787 feet below milepost 83, at the west fence on the right of way of the Chicago, Bur-

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lington and Northern Railway, directly opposite the large barn with stone foundation and basement, owned by Mr. Bartsch, and midway between two prominent points of bluff. It is 3,300 feet below T. B. M. 108 and 45 feet from center of track, being a copper bolt in tile, 3 feet under ground.

Elevation, 209.8510 meters. 688.494 feet.

P. B. M. 152 in top of cap on iron pipe set over P. B. M. 151.

Elevation, 211.0676 meters. 692.485 feet.

T. B. M. 109 is about 3½ miles above Cochrane, 300 feet below Buffalo Slough crossing, and 33 feet east from the east right of way fence, in meadow, on the large lone gnarled oak tree, being a 6-inch spike in root.

Elevation, 209.0569 meters. 685.888 feet.

T. B. M. 114 is 2,493 feet below Cochrane, Wis., on the line of the Chicago, Burlington and Northern Railway, at the road crossing on the southeast side of the wagon road, and on the northeast side of the railroad, 50 feet from center of track, on an oak stump 3 feet high, in the fence where wire connects with rail fence, being a 6-inch wire spike.

Elevation, 212.1789 meters. 696.131 feet.

P. B. M. 153 is 2,493 feet below the depot at Cochrane, at the mouth of Rose Valley, at road crossing, on the right of way of the Chicago, Burlington and Northern track, in corner of fence on the east side of track below the road, same place as T. B. M. 114, being a copper bolt in tile 3 feet below the surface of ground.

Elevation, 210.3579 meters. 690.157 feet.

P. B. M. 154 is top of cap on iron pipe set over P. B. M. 153.

Elevation, 211.5794 meters. 694.164 feet.

T. B. M. 117 is 5¼ miles above the lime kiln at the upper end of Fountain City, at the northeast corner of August Bensel's wagonhouse, on base stone, being highest point in square.

Elevation, 209.7958 meters. 688.313 feet.

P. B. M. 155 is 3¾ miles above the lime kiln at the upper end of Fountain City, at the farm residence of Peter Suter, 28 feet above the center of the Railroad Viaduct No. 439 over the wagon road, and 25 feet southwest from the center of the Chicago, Burlington and Northern track, being top of copper bolt in tile 3 feet below surface of ground.

Elevation, 206.5508 meters. 677.666 feet.

P. B. M. 156 is top of cap on iron pipe set over P. B. M. 155.

Elevation, 207.7686 meters. 681.662 feet.

T. B. M. 120 is about 2 miles above the lime kiln at upper end of Fountain City, 416 feet above milepost 94, on the west side of track, just outside of the right of way, a half mile above bridge 437, being a spike in an oak tree.

Elevation, 208.6520 meters. 684.560 feet.

T. B. M. 121 is about 1¼ miles above the lime kiln at the upper end of Fountain City, on the east side of highway, 200 feet below railroad bridge No. 437 over Maumandee Creek, in front of the southwest corner of Martin Ludwig's yard, on the opposite side of the road and 79 feet from P. B. M 157, being the highest point in square on embedded stone, marked "U. □ S."

Elevation, 207.4780 meters. 680.708 feet.

P. B. M. 157 is on the opposite side of the road and 79 feet from T. B. M. 121, about 1¼ miles above the lime kiln at the upper end of Fountain City, 331 feet below the south end of the Chicago, Burlington and Northern Bridge No. 437, over Maumandee Creek, on the right of way of the Chicago, Burlington and Northern Railway, at the east fence, being top of copper bolt leaded in tile and set three feet below surface of ground.

Elevation, 205.7895 meters. 675.168 feet.

P. B. M. 158 is top of cap on iron pipe set over P. B. M. 157.

Elevation, 207.0093 meters. 679.170 feet.

T. B. M. 122 is in the upper end of Fountain City, just east of the lime kiln, on the upper side of bridge No. 433, in the east end of cap directly over pile, being the south one of two spikes, with a square around it.

Elevation, 209.1880 meters. 686.318 feet.

Old U. S. B. M. 1 "H. W. G." is at Fountain City, Wis., 30 feet below bridge 428 of the Chicago, Burlington and Northern Railway, 50 feet east from center of track, on the south side of Eagle street, which leads to the steamboat landing, at the southwest corner of Bohrie's warehouse, on foundation stone, marked "B. M.", being the highest point of square within the circle cut in stone.

Elevation, 207.0364 meters. 679.259 feet.

Old U. S. B. M. "A" is in Fountain City, Wis., on the northwest corner of Main and Eagle streets, at the southeast corner of Sherer's Hotel, on the water table, being the highest point of triangle inside of circle marked "B. M."

Elevation, 211.0599 meters. 692.460 feet.

P. B. M. 159 is in Fountain City, Wis., east of Eagle street, on the south side of

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Main street, on Charles Niemann's saloon, on the upper end of window sill, being the top of copper bolt leaded vertically and marked "U. S." ⊙ P. B. M.

Elevation, 212.0086 meters. 695.573 feet.

Old U. S. B. M. "XXI" is just below Fountain City, behind the head of Island 62, on the river side of the Chicago, Burlington and Northern track and 40 feet below Bridge 424, 70 feet from bank of slough, being a spike in base of a soft-maple stump.

Elevation, 205.6544 meters. 674.725 feet.

T. B. M. 123 is 1¼ miles below Eagle street, Fountain City, 52 feet above milepost 98 and 10 feet northeast from center of track, on a ledge of rock at about the same elevation as the track, being highest point in square marked "U. □ S."

Elevation, 208.6378 meters. 684.513 feet.

P. B. M. 160 is 1¼ miles below Eagle street, Fountain City, 2,362 feet below the Chicago, Burlington and Northern Bridge No. 221, and 31 feet northeast from milepost 98, below large curve in railroad line, on the right of way, 1 foot from wire fence, being copper bolt leaded in tile 3 feet below the ground.

Elevation, 210.1092 meters. 689.341 feet.

P. B. M. 161 is top of cap on iron pipe set over P. B. M. 160, about a foot above ground.

Elevation, 211.3281 meters. 693.340 feet.

T. B. M. 124 is at mouth of slough opposite Island 65, 1,453 feet below milepost 99, and 840 feet below bridge 418, at the upper end of cut below Jack Cook's house, on the bluff side of track, being the highest point in square on rock, marked "U. □ S."

Elevation, 209.5997 meters. 687.669 feet.

T. B. M. 125 is at the head of Island 69, 16 feet above the overhead cable track running from the quarry to the river, on the bluff side of the Chicago, Burlington and Northern track, on large rock in side of bank, being the highest point in square, marked "U. □ S."

Elevation, 208.0797 meters. 682.682 feet.

P. B. M. 162 is at the head of Island 69, 524 feet below T. B. M. 125, on the Chicago, Burlington and Northern right of way, at the east fence, about 150 feet above viaduct over road running to the low-water landing, being copper bolt in tile, about 3 feet underground.

Elevation, 207.3962 meters. 680.440 feet.

P. B. M. 163 is top of cap on iron pipe set over P. B. M. 162.

Elevation, 208.6139 meters. 684.435 feet.

T. B. M. 126 is behind Island 69, 12 feet northeast from the Chicago, Burlington and Northern track, 715 feet below milepost 101, and 1,148 feet above bridge 415, on embedded rock, being the highest point in square marked "U. □ S."

Elevation, 208.9051 meters. 685.390 feet.

T. B. M. 127 is opposite Winona, on the east side of the Chicago, Burlington and Northern Railway, 3,280 feet above its crossing with the Chicago and Northwestern Railway, 1,640 feet above bridge 413, over slough, behind and 49 feet from milepost 102 in cut, on large rock in foot of bank, marked U. □ S., being the highest point in square.

Elevation, 209.9397 meters. 688.785 feet.

P. B. M. 164 is on the left bank of the river, opposite Winona, on the right of way of the Chicago and Northwestern Railway, at the east fence, 279 feet north from the north end of bridge over the Mississippi, being a copper bolt in tile 3 feet under ground.

Elevation, 203.5121 meters. 667.697 feet.

P. B. M. 165 is top of cap on iron pipe set over P. B. M. 164.

Elevation, 204.7251 meters. 671.676 feet.

Old U. S. B. M. XVII is at Winona, on the left bank of the river, in the abutment of the Chicago and Northwestern Railway Bridge, at the upper side of the downstream bedplate of the northeast post on line with the five rivets, being the highest point in square.

Elevation, 206.9688 meters. 679.038 feet.

P. B. M. 166 is at Winona, on the north end of the Chicago and Northwestern Railway Bridge, on the west end of first pier south of abutment, 4 feet from the north face and 2 feet from end of pier, being top of copper bolt leaded vertically and marked U. S. ⊙ P. B. M.

Elevation, 206.7248 meters. 678.237 feet.

P. B. M. 167 is in Winona, on the north wing wall, land abutment of the Chicago and Northwestern Railway Bridge, on the seventh stone step from the top, 5 inches back from its north face and 7 inches from the west face of the sixth step, being top of copper bolt leaded vertically, marked "U. S." ⊙ P. B. M.

Elevation, 207.8766 meters. 682.016 feet.

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Old U. S. and railroad gauge is at Winona, in center of crib-work below the draw pier of the Chicago and Northwestern Railway Bridge, being a staff gauge spiked to timber of crib, graduated to feet and tenths.

Elevation of its zero, 201.2576 meters. 660.300 feet.

New gauge is at Winona, on the Chicago and Northwestern Railway Bridge, on the pier at the south end of drawbridge, at the lower part of its river face, dressed in the masonry to feet and tenths.

Elevation of its zero, 201.2695 meters. 660.339 feet.

Old U. S. B. M. "b" is in Winona, on the down-river side of the Winona Water Works engine house, on the river end of the stone door sill of door toward river, being the highest point in circle.

Elevation, 207.0912 meters. 679.439 feet.

Winona City B. M. is in Winona, Minn., at the entrance to the water-works standpipe, on the west end of bottom step, being marked by a light cross. Elevation, Winona datum, 94.058 feet.

Elevation, 206.7659 meters. 678.372 feet.

Old U. S. B. M. is in Winona, on the east face of water tower, on the bottom surface of a deep notch cut in base stone about 2 feet above ground, being the highest point in square, on river side of old line.

Elevation, 206.9965 meters. 679.128 feet.

P. B. M. 168 is in Winona, Minn., in the court-house on the north front of the west window sill, about 1 foot above ground, being top of copper bolt leaded vertically,

"U. S."
marked ⊙
P. B. M.

Elevation, 209.2616 meters. 686.560 feet.

Old U. S. B. M. "B" of gauge record is in Winona, on the southwest corner of East Front and Franklin streets, opposite L. C. Porter's mill, at the front door of brick office on the downstream end of step, being the highest point in square.

Elevation, 206.6312 meters. 677.930 feet.

Old U. S. B. M. on Liberty and Second streets is in Winona, on the southwest corner of East Second and Liberty streets, on the upstream end of the west window sill, 19.7 feet west from the east corner of building, being the high point in rear part of square.

Elevation, 207.6605 meters. 681.307 feet.

Old U. S. B. M. on Keys's barn, in lower Winona, 492 feet above the Winona and Southwestern and Chicago, Burlington and Northern Railway Bridge across the Mississippi, on the north side of approach, just in the rear of Mr. Keys's house, on brick barn, on the upstream end of the stone window sill of window facing river, being the high point in rear part of old square.

Elevation, 209.6838 meters. 687.945 feet.

P. B. M. 169 is in lower Winona, on the Winona and Southwestern and Chicago, Burlington and Northern Railway Bridge, on the upstream end of the first pier from the abutment, on the southwest corner of coping stone, being top of copper bolt

"U. S."
leaded vertically, marked ⊙
P. B. M.

Elevation, 208.5111 meters. 684.098 feet.

T. B. M. 128 is in Lower Winona, 2,214 feet below the Winona and Southwestern Railway Bridge, 125 feet back southwest from the lower ice house on the river bank, 140 feet northeast from the railroad track, on a large willow tree, blazed, being the top of a 6-inch wire spike.

Elevation, 202.9988 meters. 666.013 feet.

T. B. M. 129 is at Minneopa below Winona, 1,272 feet above milepost 117, on the southwest side of the Chicago, Milwaukee and St. Paul track, and on the lower side of the mouth of Pine Creek (being the first creek below Winona), in E. A. Goodfellow's front yard, on the north root of a 2-foot willow tree, being top of a 6 inch wire spike.

Elevation, 205.4574 meters. 674.079 feet.

P. B. M. 170 is at Minneopa below Winona, on the southwest side of the Chicago, Milwaukee and St. Paul track, 82 feet below the lower end of bridge over Pine Creek, which is the first creek below Winona, in E. A. Goodfellow's front yard, about 45 feet below T. B. M. 129, 1½ feet southwest from front fence, being a copper bolt in tile, 3 feet underground.

Elevation, 204.3693 meters. 670.509 feet.

P. B. M. 171 is top of cap on iron pipe set over P. B. M. 170.

Elevation, 205.5861 meters. 674.501 feet.

T. B. M. 130 is 2.6 miles below the Winona and Southwestern Railway Bridge, across the Mississippi at lower Winona, 3,182 feet above Homer and 1,804 feet below milepost 117 of the Chicago, Milwaukee and St. Paul track, 10 feet northeast from

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the center, at the mouth of a wooden box drain, on a large rock, being the highest point in square, marked "U. □ S."

Elevation, 206.1020 meters. 676.194 feet.

T. B. M. 131 is 2,920 feet below Station Homer, and 1,686 feet below bridge 42, 10 feet southwest from center of track, 367 feet below P. B. M. 172 and 173, on rock, being the highest point in a square, marked U. □ S.

Elevation, 207.4652 meters. 680.666 feet.

P. B. M. 172 is 2,552 feet below Station Homer, on the bluff side of the Chicago, Milwaukee and St. Paul track, 1 foot east from the fence, in front of Mr. Wm. Besner's brick house, on the hill, opposite a lone hickory tree, standing on the bluff side of the wagon road, being a copper bolt in tile 3 feet below surface of ground.

Elevation, 206.7217 meters. 678.227 feet.

P. B. M. 173 is top of cap on iron pipe set over P. B. M. 172.

Elevation 207.9382 meters. 682.218 feet.

T. B. M. 132 is opposite the foot of Island 75, on line of Chicago, Milwaukee and St. Paul track, 2,371 feet above milepost 120, 15 feet north from the center of track on embedded rock, marked "U. □ S.," being the highest point in square.

Elevation, 206.7558 meters. 678.339 feet.

T. B. M. 133 is opposite the closing dike of Island 76, 594 feet below Bridge 36, on the line of the Chicago, Milwaukee and St. Paul track, 15 feet north from center, on an embedded rock, marked "U. □ S.," being the highest point in square.

Elevation, 207.4723 meters. 680.690 feet.

P. B. M. 174 is 2¼ miles below Homer, opposite the end of closing dike behind Island 76, 656 feet below bridge 36, on the Chicago, Milwaukee and St. Paul right of way, at the bluff side fence, and 984 feet below milepost 120, being a copper bolt in tile 3 feet under ground, 75 feet more or less below T. B. M. 133, and about 15 feet above grade of track.

Elevation, 210.0438 meters. 689.126 feet.

P. B. M. 175 is top of cap on iron pipe set over P. B. M. 174.

Elevation, 211.2635 meters. 693.128 feet.

T. B. M. 134 is between islands 76 and 77, 1,745 feet above milepost 121 and 269 feet below bridge 34 of the Chicago, Milwaukee and St. Paul track, 10 feet beyond the southwest right-of-way fence, in the 10-inch cottonwood tree, being top of a wire spike.

Elevation, 206.6935 meters. 678.134 feet.

T. B. M. 135 is opposite the foot of Island 77, 4,593 feet above the La Moille, 1,952 feet below center of bridge 32 of the Chicago, Milwaukee and St. Paul track, and 1,666 feet above milepost 122 from St. Paul, at the upper end of cut, 8 feet northeast from center of track, on an embedded bowlder, marked "U. □ S.," being the highest point in square.

Elevation, 206.2219 meters. 676.587 feet.

T. B. M. 137 is, at La Moille, Minn., about 328 feet below the depot of the Chicago, Milwaukee and St. Paul, on the northeast corner of sill supporting the railroad wheat house, being the top of a 6-inch spike in sill.

Elevation, 206.2943 meters. 676.825 feet.

P. B. M. 176 is at La Moille, 154 feet above the Chicago, Milwaukee, and St. Paul, Depot, at foot of bluff, 50 feet southwest from center of track, 35 feet above the upper end of bridge, and 69 feet below the frame house, being top of a copper bolt in tile, about 475 feet above T. B. M. 137.

Elevation, 205.5603 meters. 674.416 feet.

P. B. M. 177 is top of cap on iron pipe set over P. B. M. 176.

Elevation, 206.7757 meters. 678.404 feet.

Old U. S. B. M. 120 is about 1 mile below La Moille, 260 feet below the lower end of switch and siding, 75 feet towards the river from center of track, and 100 feet back from bank of slough, being a spike in a lone oak tree.

Elevation, 203.8975 meters. 668.961 feet.

T. B. M. 140 is about 1¾ miles below La Moille, 1,640 feet below Bridge 22, on the south side of track, 39 feet from the center, 1,361 feet below milepost 124, at the south end of fill and the north end of cut, 180 feet above the line of upper side of white house, being top of a 6-inch spike in a charred stump.

Elevation, 205.7164 meters. 674.929 feet.

T. B. M. 141 is opposite the head of Island 86, 574 feet below milepost 125, 40 feet east of track center, being a 6-inch spike in the root of an oak tree about 9 inches in diameter, blazed.

Elevation, 208.4149 meters. 683.782 feet.

T. B. M. 142 is about 1 mile above Richmond, at E. Leach's crossing, just above the upper roadside fence, 15 feet east of center of track, on an embedded bowlder, being the highest point in square, marked "U. □ S."

Elevation, 210.3824 meters. 690.237 feet.

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P. B. M. 178 is in Richmond, Minn., 1,900 feet below bridge 16 and 615 feet above the upper end of siding, 101 feet above the upper end of Jacob Danehower's house, 105 feet below the lower end of barn, 47 feet west of center of the Chicago, Milwaukee and St. Paul track, being top of copper bolt in tile set 3 feet below surface of ground.

Elevation, 205.9664 meters. 675.749 feet.

P. B. M. 179 is top of cap on iron pipe set over P. B. M. 178.

Elevation, 207.1862 meters. 679.751 feet.

T. B. M. 144 is in front of Queens Bluff in Richmond, 639 feet above milepost 127, about at the center of siding, 12 feet east of track center, on the ledge of rock in small cut, being highest point in square, marked "U. □ S."

Elevation, 206.0392 meters. 675.988 feet.

T. B. M. 146 is 2½ miles above Dakota, just above Island 90, 656 feet above Henry Winter's house, on the line of the Chicago, Milwaukee and St. Paul Railway, 12 feet west of center of track, being the highest point in square, marked "U. □ S."

Elevation, 210.7417 meters. 691.416 feet.

P. B. M. 180 is about 1¼ miles below Richmond, 787 feet below the line of dike above the head of Island 90, and 285 feet above the house of Henry Winters, directly opposite the farm crossing, 39 feet from center of track towards the river, also 39 feet back from top of river bank, being copper bolt in tile, 3 feet underground.

Elevation, 208.2197 meters. 683.142 feet.

P. B. M. 181 is top of cap on iron pipe set over P. B. M. 180.

Elevation, 209.4416 meters. 687.151 feet.

T. B. M. 147 is 2 miles above Dakota, opposite the foot of Island 90, 728 feet below milepost 129 and 30 feet east from the center of track, on an oak tree 1 foot in diameter, with top broken off, being spike in root.

Elevation, 207.8849 meters. 682.043 feet.

P. B. M. 182 is at Dakota, Minn., 656 feet above the Chicago, Milwaukee and St. Paul Depot, and 430 feet below mile post 131, on the west side of wagon road, 262 feet west from center of track on line with the stone fence in front of Amos Shay's residence, and 13 feet above its upper end, also 69 feet from a lone blazed cottonwood tree standing on the east side of wagon road, engraved "U. S." P. B. M., being copper bolt in tile 3 feet underground.

Elevation, 208.1715 meters. 682.983 feet.

P. B. M. 183 is top of cap on iron pipe set over P. B. M. 182.

Elevation, 209 3905 meters. 686.983 feet.

Old U. S. B. M. 131 is in Dakota, Minn., 269 feet below the Chicago, Milwaukee and St. Paul Depot, 9¼ feet west from center of track, on the water-tank foundation, at the lower side, front pier, on the southeast corner of base stone, being the highest point in circle "⊙."

Elevation, 205.1113 meters. 672.943 feet.

T. B. M. 150 is 2,493 feet above R. Remp's store in Dresbach, Minn., 1 mile below Dakota, and 1,542 feet below milepost 132, on line of Chicago, Milwaukee and St. Paul track, 30 feet west from the center, and 328 feet above John Wagner's house, on a large oak stump, being top of a 6-inch wire spike.

Elevation, 213.7706 meters. 701.353 feet.

Old U. S. B. M. 130½, also called Old P. B. M. 18, is in the upper end of Dresbach, on the east end of stone culvert, under high fill, 200 feet from the river, on the southeast corner of coping stone, being the highest point in circle cut on the sandstone.

Elevation, 203.7340 meters. 668.425 feet.

P. B. M. 184 is in Dresbach, Minn., on the northwest corner of Second and G streets, on the front of R. Remp's brick store, on the south end of the stone doorstep, being the top of copper bolt leaded vertically, marked "U. S." ⊙ P. B. M.

Elevation, 216.3510 meters. 709.819 feet.

T. B. M. 151 is about 3,609 feet below Dresbach, and 2,792 feet below milepost 133, on line of Chicago, Milwaukee and St. Paul Railway track, 12 feet east from center, on an embedded bowlder, being highest point in square, marked "U. □ S."

Elevation, 207.2770 meters. 680.049 feet.

P. B. M. 185 is about 3,609 feet below Dresbach, on opposite side of track from T. B. M. 151, 425 feet below Henry Becker's house, and 280 feet above his limekiln, 62.7 feet below the head block at upper end of siding, at west fence, and 48.7 feet west from center of track, being copper bolt in tile 3 feet underground.

Elevation, 206.1904 meters. 676.484 feet.

P. B. M. 186 is top of cap on iron pipe set over P. B. M. 185.

Elevation, 207.4126 meters. 680.494 feet.

T. B. M. 153 is at the mouth of Dresbach Slough, 1,079 feet above milepost 135, on the bank of the Chicago, Milwaukee and St. Paul Railway track, 12 feet west from center, on a rock marked U. □ S., being the highest point in square.

Elevation, 208.3287 meters. 683.499 feet.

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T. B. M. 154 is 1¼ miles above "River Junction," on the line of the Chicago, Milwaukee and St. Paul Railway track, about 100 feet above "Ferndale Cottage," and 65 feet below the very large and conspicuous bowlder on the west side of west ditch, 196 feet above milepost 136, on an embedded bowlder, marked "U. □ S.", being the highest point in square.

Elevation, 207.4100 meters. 680.485 feet.

P. B. M. 187 is above La Crescent, about 1,320 feet above the depot at River Junction, and 915 feet above the head block at the lower end of siding, 400 feet below J. A. Selzer's stone house, and 95 feet above Mr. Edwards's house, on the bluff side of the Chicago, Milwaukee and St. Paul Railway track, 66 feet from center, and 48 feet from side track, being copper bolt in tile 3 feet underground.

Elevation, 205.1134 meters. 672.950 feet.

P. B. M. 188 is top of cap on iron pipe set over P. B. M. 187.

Elevation, 206.3383 meters. 676.969 feet.

T. B. M. 155 is above La Crescent, and 590 feet above "River Junction" depot, 50 feet west from the center of the Chicago, Milwaukee and St. Paul Railway track, on a land monument, which is a square stone set in the ground, and standing 2 feet above surface, marked on top with a diagonal line and a figure "3," being the highest point in the upper part of the figure "3."

Elevation, 202.4259 meters. 664.133 feet.

Old U. S. B. M. 139, also called old P. B. M. 19, is on the right bank, on the west pier of the Chicago, Milwaukee and St. Paul Railway Bridge, across the Mississippi above La Crosse, on the upstream point or nose of capstone, being the highest point in small square in the south part of old circle.

Elevation, 204.7267 meters. 671.682 feet.

P. B. M. 189 is on the west pier of the Chicago, Milwaukee and St. Paul Railway Bridge above La Crosse, on the same pier as old B. M. 139, lower side of track, on the downstream end of capstone, being a copper bolt leaded vertically, marked U.S. ⊙ P.B.M.

Elevation, 205.2345 meters. 673.348 feet.

Gauge, U. S. and Railroad, is at the draw of the Chicago, Milwaukee and St. Paul Railway Bridge above La Crosse, on the upper side of the bridge, on the southwest corner of the upper breakwater crib, a staff gauge spiked to the timber.

Elevation of its zero, 197.7253 meters. 648.711 feet.

P. B. M. 190 is on the east pier of the Chicago, Milwaukee and St. Paul Railway Bridge, over the east channel of the Mississippi River above La Crosse, on the downstream side directly south from center of shoe, 9 inches from face of stone, being top of copper bolt leaded vertically, marked "U.S." ⊙ P.B.M.

Elevation, 205.2576 meters. 673.423 feet.

T. B. M. 157 is in North La Crosse, in the west pier of drawbridge, over Black River No. 0, in the north end of pier, being highest point in square cut on coping stone.

Elevation, 204.0668 meters. 669.516 feet.

P. B. M. 191 is in North La Crosse on the Chicago, Milwaukee and St. Paul Railway Bridge No. 0, over Black River, in the south side of the east pier, 15 inches from the southwest corner, being top of a copper bolt leaded vertically, marked "U.S." ⊙ P.B.M.

Elevation, 203.3528 meters. 667.174 feet.

T. B. M. 158 is in North La Crosse, near the entrance to the Chicago, Milwaukee and St. Paul roundhouse, in the water tank foundation stone, the northwest pier, on beveled edge of the top stone in broken square, marked U. □ S.

Elevation, 203.0160 meters. 666.069 feet.

La Crosse City B. M., on Front street, is on the west side of Front street between Main and Pearl streets, on the southeast corner of old building joined to the south side of stone building, on the top surface of water table, 0.7 foot above the lower corner, being the highest point in square. The building is occupied by "S. Becker—Commission and Produce." Elevation, Lacrosse datum, 50.000 feet.

Elevation, 204.7179 meters. 671.653 feet.

P. B. M. 192 is in La Crosse, Wis., on the United States post-office building, on the northeast corner of Fourth and State streets, at the south side of the south one of three doors fronting on Fourth street, being the door next to the tower, a copper bolt leaded vertically in the doorstep, marked "U.S." ⊙ P.B.M.

Elevation, 213.2996 meters. 699.808 feet.

T. B. M. 160 is in La Crosse on the west side of the Chicago, Burlington and Northern depot, on the Second street side, at the south side of second door above the south end of main building, being the highest point in square marked "U. □ S."

Elevation, 206.5767 meters. 677.751 feet.

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La Crosse City B. M., at east end of bridge, is in La Crosse just north of the land pier to wagon bridge across the Mississippi, on the southwest corner of the small brick building, 1 foot above the south corner and 0.8 foot above the ground, being the bottom of a notch cut in the brick. Elevation, Lacrosse, datum, 39.510 feet.

Elevation, 201.5321 meters. 661.200 feet.

P. B. M. 193 is in La Crosse in the west face of the land pier to the highway bridge across the Mississippi, 5 feet from its north end and 3.5 feet above ground, being the center of a copper bolt leaded horizontally, marked "U. S." ⊙ P. B. M.

Elevation, 202.4379 meters. 664.172 feet.

U. S. Signal Service gauge is in La Crosse, Wis., about 262 feet below the wagon bridge across the Mississippi, a graduated staff, fastened to a cluster of three piles.

Elevation of its zero, 196.7079 meters. 645.373 feet.

T. B. M. 161 is in La Crosse, one-half mile below the highway bridge across the Mississippi, on the southeast corner of First and Market streets, on the brick building of the La Crosse Soap Company, on the First street front, on the south end of a stone doorstep, being highest point in square, marked "U. □ S."

Elevation, 207.4536 meters. 680.628 feet.

T. B. M. 162 is in the south end of La Crosse, on John Gund's stone brewery, 60 feet south from center of track, 8.4 feet west from the east corner, on the sloping water table, being highest point in square marked "U. □ S."

Elevation, 211.6585 meters. 694.424 feet.

P. B. M. 194 is on the line of the Chicago, Burlington and Northern Railway, 2 miles below the brewery at south end of La Crosse, on the right of way at the west wire fence, opposite South Junction depot, and 33 feet south of the same, being copper bolt in tile, 3 feet under ground.

Elevation 204.1680 meters. 669.849 feet.

P. B. M. 195 is top of cap on iron pipe set over P. B. M. 194.

Elevation, 205.3857 meters. 673.844 feet.

T. B. M. 168 is 3¾ miles above Stoddard, Wis., 3,281 feet below mile post 139, and 870 feet above milepost 140, 20 feet west of center of Chicago, Burlington and Northern Railway, close to the north side of farm crossing, in the same locality as P. B. M. 196 and 197, being top of spike in stump.

Elevation, 201.6789 meters. 661.682 feet.

P. B. M. 196 is 3¾ miles above Stoddard, Wis., on the line of the Chicago, Burlington and Northern Railway, 870 feet above milepost 140, about one-half mile below Jack Branak's house and saloon, and one-fifth mile above Carl Bay's house, 21 feet below the gate to farm crossing, on right of way, 2 feet from the east fence, being copper bolt in tile, 3 feet under ground.

Elevation, 202.2358 meters. 663.509 feet.

P. B. M. 197 is top of cap on iron pipe set over P. B. M. 196.

Elevation, 203.4494 meters. 667.491 feet.

T. B. M. 170 is 2½ miles above Stoddard, Wis., 2,526 feet below milepost 141, 15 feet east of center of track, about half way through large cut on imbedded bowlder, being the highest point in square, marked "U. □ S."

Elevation, 202.1210 meters. 663.133 feet.

T. B. M. 172 is about 3,281 feet above Stoddard, near the upper end of the first tangent above the depot, 853 feet below milepost 143, and 328 feet below the farm crossing, 25 feet east from center of the Chicago, Burlington and Northern track, on imbedded bowlder, being the highest point in square, marked "U. □ S."

Elevation, 201.5432 meters. 661.237 feet.

P. B. M. 198 is in Stoddard, Wis., on foundation to water tank, on the northeast corner of the northeast pier being top of copper bolt leaded vertically, and marked "U. S." ⊙ P. B. M.

Elevation, 202.9203 meters. 665.755 feet.

T. B. M. 173 is 1¾ miles above Warners Landing, Wisconsin, on bridge 346 over the Raccoon River, on the east end of the first cap from the south end of the bridge, over a large pile, being top of drift bolt inside of square.

Elevation, 201.2497 meters. 660.274 feet.

P. B. M. 199 is at Warners Landing, 280½ feet up the track from O. Warner's house, 60 feet above bridge 342, and 29.2 feet east of the center of the track, on the Chicago, Burlington and Northern Railway right of way, at the east fence, being copper bolt in tile, 3 feet under ground.

Elevation 200.2504 meters. 656.995 feet.

P. B. M. 200 is top of cap on iron pipe set over P. B. M. 199.

Elevation, 201.4690 meters. 660.993 feet.

T. B. M. 174 is at Warners Landing, Wisconsin, in front of O. Warner's house on the

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Chicago, Burlington and Northern right of way, 6 feet from the east fence, being spike in stump.

Elevation, 200.6003 meters. 658.143 feet.

T. B. M. 175 is at Britts Landing, 75 feet above milepost 147, on the east side of track, on a rock, being the highest point in square, marked "U. □ S."

Elevation, 202.3602 meters. 663.917 feet.

P. B. M. 201 is 1⅝ miles above Genoa, 351 feet below bridge 333, and 1,837 feet above milepost 148, on the right of way of the Chicago, Burlington and Northern Railway, at the east fence, between road and highway, in front of Frank Riley's property, being copper bolt in tile, 3 feet under ground.

Elevation, 200.7226 meters. 658.545 feet.

P. B. M. 202 is top of cap on iron pipe set over P. B. M. 201.

Elevation, 201.9462 meters. 662.559 feet.

T. B. M. 177 is 1¼ miles above Genoa depot, on line of the Chicago, Burlington and Northern Railway, 2,516 feet below milepost 148, and 656 feet above P. B. Ms. 201 and 202, 12 feet east of center of track on a large rock, being highest point in square, marked "U. □ S."

Elevation, 201.2893 meters. 660.404 feet.

T. B. M. 178 is one-half of a mile above Genoa, Wis., 2,326 feet below milepost 149, in front of the large stone house of John Franzini, on rough bowlder, on the east side of the highway which runs along east of railroad, being the highest point in square, marked "U. □ S."

Elevation, 201.8655 meters. 662.294 feet.

P. B. M. 203 is in Genoa, Wis., on the west side of the main street in front of Albert Zabolio's store, on the stone doorstep of the upstream door, near the southeast corner step, being the top of copper bolt leaded vertically, marked "U. S." ⊙ P. B. M.

Elevation, 206.3376 meters. 676.967 feet.

Old U. S. B. M. "i," also called old P. B. M. 21, is in Genoa, Wis., on the last stone building in the town going south, on the side of the building facing the river, second floor, on the upstream corner of the stone doorsill, being highest point in square.

Elevation, 201.2247 meters. 660.192 feet.

T. B. M. 180 is 1 mile below Genoa, 187 feet below bridge 327, and 174 feet above milepost 151, 19 feet east of center of track, being a large spike in an oak stump.

Elevation, 201.7758. 662.000 feet.

T. B. M. 182 is about 2¼ miles above Tippets Landing, Wisconsin, 103 meters below milepost 153 and 170 feet above bridge No. 322, on the east side of the Chicago, Burlington and Northern Railway, in small lane on the land of John T. Elger, on a large, new stump, being the top of a large spike.

Elevation, 201.0404 meters. 659.587 feet.

P. B. M. 204 is 2¾ miles below Genoa and 23 feet below T. B. M. 182, 147 feet above bridge No. 322 and 93.5 feet below John T. Elger's house, on the right of way of the Chicago, Burlington and Northern Railway, 34.5 feet east from center of track, being copper bolt in tile, buried 3 feet underground.

Elevation, 199.5226 meters. 654.608 feet.

P. B. M. 205 is top of cap on iron pipe set over P. B. M. 204.

Elevation, 200.7415 meters. 658.607 feet.

T. B. M. 186 is at Tippets Landing, Wisconsin, 1,640 feet below Mr. Tippet's house, and 1,128 feet below the warehouse on the river bank, 12 feet west of the center of the Chicago, Burlington and Northern Railway, on an imbedded rock, being the highest point in square marked "U. □ S."

Elevation, 201.5322 meters. 661.201 feet.

P. B. M. 206 is at Tippets Landing, about 150 feet below T. B. M. 186 and 1,296 feet below the old warehouse, on the east side of the Chicago, Burlington and Northern Railway, 33¼ feet from the center. It is also 1 mile above Victory, in the bed of the old wagon road under the bluff used before the railroad was built, being top of copper bolt leaded in tile, set 3 feet underground.

Elevation, 202.0378 meters. 662.860 feet.

P. B. M. 207 is top of cap on iron pipe set over P. B. M. 206.

Elevation, 203.2601 meters. 666.870 feet.

P. B. M. 208 is in Victory, Wis., on the southeast corner of block 17 and at the northeast corner of Terhune and Rice streets, on the south abutment, west side of wagon bridge, on the corner top stone, 3 inches from end of wall, being top of copper bolt leaded vertically, marked "U. S." ⊙ P. B. M.

Elevation, 201.3365 meters. 660.559 feet.

T. B. M. 188 is 1 mile below Victory Depot, on line of the Chicago, Burlington and Northern Railway, 2,100 feet above milepost 158 and 197 feet above bridge No. 309,

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30 feet east of center of track, on an imbedded bowlder, marked "U. ◻ S.," being the highest point in square.

Elevation, 200.7365 meters. 658.590 feet.

T. B. M. 190 is 2¼ miles above De Soto, in the same vicinity as P. B. M.'s 209 and 210, on the line of the Chicago, Burlington and Northern Railway, on Bridge No. 307, over Battle Creek, in the seventh bent from the south end, on the west end of cap, being top of spike in square.

Elevation, 199.2840 meters. 653.825 feet.

P. B. M. 209 is 2¼ miles above De Soto, 164 feet east from Bridge No. 307, over Battle Creek and 36 feet east of wagon road, at the north side of north wire fence of lane leading from Richard Valliant's house, being copper bolt in tile buried about 3 feet underground.

Elevation, 199.1689 meters. 653.447 feet.

P. B. M. 210 is top of cap on iron pipe set over P. B. M. 209.

Elevation 200.3905 meters. 657.455 feet.

T. B. M. 192 is about a mile above De Soto, Wis., 1,138 feet above milepost 160, in cut 12 feet east from the center of the Chicago, Burlington and Northern Railway, on an imbedded bowlder, being the highest point in square, marked "U. ◻ S."

Elevation, 200.6101 meters. 658.176 feet.

T. B. M. 193 is in the upper end of De Soto, at the warehouse formerly owned by "C. Lytel & Co.," now owned by the De Soto Lumber Company, on the south end of the south top stone of pier supporting runway over the Chicago, Burlington and Northern Railway track, 7.2 feet east from the center of track, being highest point in square marked "U. ◻ S."

Elevation, 201.8655 meters. 662.294 feet.

P. B. M. 211 is in the upper end of De Soto, on the north side of the Diamond Joe Warehouse, 9 inches from the west side and 5.3 feet above the ground, being the center mark in copper bolt leaded horizontally, marked "U. S." ⊙ P. B. M.

Elevation, 197.1060 meters. 646.679 feet.

P. B. M. 212 is in De Soto, in the foundation of water tank of the Chicago, Burlington and Northern Railway, in top stone of the south one of the two west piers, being top of copper bolt leaded vertically, marked "U. S." ⊙ P. B. M.

Elevation, 200.1458 meters. 656.652 feet.

T. B. M. 195 is 1¾ miles below De Soto, 860 feet below bridge No. 298 and 360 feet below milepost 163, 15 feet west of center of track, being highest point in square on rock, marked "U. ◻ S."

Elevation, 200.1564 meters. 656.687 feet.

P. B. M. 213 is 1¾ miles below De Soto and 394 feet below milepost 163, at the upper end of the stretch where the Winneshiek Slough comes back to the railroad, on the right of way of the Chicago, Burlington and Northern Railway, at the west fence, 26 feet from center of track at lower end of the rock cut and 32 feet below T. B. M. 195, being copper bolt in tile set about 3 feet below surface of ground.

Elevation, 198.6721 meters. 651.817 feet.

P. B. M. 214 is top of cap on iron pipe set over P. B. M. 213.

Elevation, 199.8813 meters. 655.784 feet.

T. B. M. 196 is about 2 miles below De Soto, 1,315 feet above milepost 164, 361 feet above bridge No. 294, and 90 feet above an exceedingly large rock at the east railroad fence, in a small cut at the foot of the east slope, 12 feet from the center of the Chicago, Burlington and Northern Railway, on an imbedded bowlder, being the highest point in square, marked "U. ◻ S."

Elevation, 199.8900 meters. 655.813 feet.

T. B. M. 197 is 1¼ miles above Rush Creek, 2,699 feet below milepost 164 and 60 meters above the small waterway under bridge No. 291, directly under a very prominent point of bluff on the east side of the Chicago, Burlington and Northern Railway, 20 feet from the center, on a large flat rock, imbedded and inclining towards the south, being the highest point in square, marked "U. ◻ S."

Elevation, 200.1152 meters. 656.552 feet.

T. B. M. 198 is about 2¼ miles above Ferryville Depot of the Chicago, Burlington and Northern Railway, in Wisconsin, and 88 meters below milepost 166, also 377 feet below the south end of long trestle over Rush Creek, on the east side of the Chicago, Burlington and Northern Railway, at the right-of-way fence, 17 feet from center of track, on a large rock imbedded, being the highest point in square, marked "U. ◻ S."

Elevation, 199.2336 meters. 653.659 feet.

P. B. M. 215 is about 2¼ miles above Ferryville Depot, Wis., 18 feet below T. B. M. 198, 394 feet below the lower end of long trestle over Rush Creek, and 94 meters below milepost 166, opposite a blazed elm standing on the east side of wagon road; also

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328 feet below a blazed elm between railroad and wagon road near south end of trestle, being a copper bolt in tile about 3 feet underground.

Elevation, 198.8436 meters. 652.380 feet.

P. B. M. 216 is top of cap on iron pipe set over P. B. M. 215.

Elevation, 200.0642 meters. 656.384 feet.

T. B. M. 200 is 4,593 feet above Ferryville, on line of the Chicago, Burlington and Northern Railway, near the upper end of the first cut above Ferryville, 1,256 feet above milepost 168 and 213 feet above bridge No. 282, 10 feet east of center of track, on a large, flat rock imbedded, being the highest point in square, marked "U. □ S."

Elevation, 199.0291 meters. 652.988 feet.

P. B. M. 217 is in Ferryville, Wis., 164 feet above the Chicago, Burlington and Northern Depot and 29½ feet east of center of track, 39 feet from the southeast corner of J. S. Oleson's house and store, all at the upper side of road crossing, being a copper bolt in tile set 3 feet underground.

Elevation, 197.8098 meters. 648.988 feet.

P. B. M. 218 is top of cap on iron pipe set over P. B. M. 217.

Elevation, 199.0313 meters. 652.996 feet.

T. B. M. 202 is 1½ miles below Ferryville, at the lower end of a light cut, 256 feet below milepost 170, 12 feet west of the Chicago, Burlington and Northern track, on a hard gray sandstone, imbedded and marked "U. □ S.," being the highest point in square.

Elevation, 199.7902 meters. 655.486 feet.

T. B. M. 203 is 2½ miles below Ferryville, at railroad fence, on the west side of the Chicago, Burlington and Northern track, opposite milepost 171, on an oak tree 20 inches in diameter (another oak tree stands perhaps 50 feet below and nearer track), being top of a large spike.

Elevation, 197.3114 meters. 647.353 feet.

T. B. M. 204 is 4 miles below Ferryville, Wis., at the place where the Winneshiek Slough comes into railroad, 1,247 feet below milepost 172, on the north side of Bridge No. 273, east of track, at corner of fence, on an imbedded bowlder, marked "U. □ S.," being the highest point in square.

Elevation, 198.0957 meters. 649.926 feet.

P. B. M. 219 is 4 miles below Ferryville, Wis., at the place where the Winneshiek Slough comes into railroad, opposite the south end of bridge No. 273, 46 feet east from the center of the track, 15 feet west from wagon road, and 15 feet south from center of bridge or "cattle pass," in the corner of fence, being a copper bolt in tile 3 feet underground.

Elevation, 196.4751 meters. 644.609 feet.

P. B. M. 220 is top of cap on iron pipe set over P. B. M. 219.

Elevation, 197.6935 meters. 648.607 feet.

P. B. M. 221 is about 1½ miles above Lynxville, Wis., at Coopers Coulee, 731 feet above Bridge 269 and 56 feet above milepost 175, 35 feet west of center of the Chicago, Burlington and Northern Railway track, outside of right of way, about 1½ feet from fence and 25 feet east from a forked oak tree, being a copper bolt in tile set about 3 feet underground.

Elevation, 198.0511 meters. 649.780 feet.

P. B. M. 222 is top of cap on iron pipe set over P. B. M. 221.

Elevation, 199.2712 meters. 653.783 feet.

T. B. M. 206 is about 10 feet down the track from P. B. M. 222, 1½ miles above Lynxville, at the upper side of Coopers Coulee, 722 feet above bridge No. 269 and 46 feet above milepost 175, 12 feet west of center of the Chicago, Burlington and Northern Railway track, on imbedded rock, marked "U. □ S.," being highest point in square.

Elevation, 198.9752 meters. 652.812 feet.

T. B. M. 207 is in the north end of Lynxville, at the Chicago, Burlington and Northern depot, on foundation stone of water tank, on the south one of the two west piers, being top of copper bolt leaded vertically, marked "U.S." ⊙ P. B. M.

Elevation, 199.6981 meters. 655.183 feet.

Old U. S. B. M. is on Bright's warehouse, in Lynxville, Wis., on the northeast corner of warehouse, 984 feet below the Chicago, Burlington and Northern Railway depot, on top of foundation, being the highest point in circle, marked "B. ⊙ M." (There is described another bench on the northwest corner of this building.)

Elevation, 200.5493 meters. 657.976 feet.

P. B. M. 223 is in Lynxville, Wis., on the north side of the principal street running back from the river, on the south front of Mr. King's brick store, in the east end of the door sill, being top of copper bolt leaded vertically, and marked "U.S." ⊙ P. B. M.

Elevation, 200.7325 meters. 658.577 feet.

T. B. M. 209 is about three-fourths of a mile below Lynxville, 623 feet below bridge

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No. 266, in the middle of light cut, 66 feet below milepost 177, on the west side of the Chicago, Burlington and Northern Railway track, 12 feet from center, on large imbedded bowlder, marked "U. □ S.," being the highest point in square.

Elevation, 198.9561 meters. 652.749 feet.

T. B. M. 211 is at Viola, about 3¼ miles below Lynxville, 1,345 feet below bridge 261, near the upper end of the first cut, 525 feet below Mr. Caya's house, just above a large cubical rock lying at water's edge, and 12 feet east from center of track of the Chicago, Burlington and Northern Railway, on a rock marked "U. □ S.," being highest point in square.

Elevation, 198.9060 meters. 652.585 feet.

P. B. M. 224 is at Viola, about 3⅛ miles below Lynxville, 909 feet below bridge No. 261, being 43.6 feet above T. B. M. 211, in the southwest corner of Mr. Caya's dooryard, 95 feet from the southwest corner of his red frame house, 50 feet southeast from track, and 1 foot north from line of fence, being a copper bolt in tile set 3 feet under ground.

Elevation, 198.1377 meters. 650.064 feet.

P. B. M. 225 is at Viola, being top of cap on iron pipe set over P. B. M. 224.

Elevation, 199.3561 meters. 654.061 feet.

T. B. M. 212 is one-half mile below Viola, 702 feet above milepost 180, 9.3 feet east of the center of the Chicago, Burlington and Northern Railway track, on natural ledge of rock, marked "U. □ S.," being the highest point in square.

Elevation, 199.6170 meters. 654.917 feet.

T. B. M. 213 is 1½ miles below Viola, about in center of the first cut below bridge No. 260, 639 feet distant, and 1,529 feet above milepost 181, 3 feet above grade on natural ledge of rock, marked "U. □ S." on face, being the highest point in square.

Elevation, 199.7723 meters. 655.427 feet.

T. B. M. 215 is about 1 mile above Charme, Wis., on the line of the Chicago, Burlington and Northern Railway, at the lower end of wooded point of land at shore, and 689 feet below the large flat piece of ledge standing on edge between railroad and river, 16 feet high; it is also 55 meters below bridge No. 256, and 1,959 feet above milepost 183, 30 feet from center of track, on an imbedded bowlder, marked "U. □ S.," being the highest point in square.

Elevation, 197.8764 meters. 649.207 feet.

P. B. M. 226 is about 1 mile above Charme, Wis., on the line of the Chicago, Burlington and Northern Railway, at the lower end of wooded strip at shore, 689 feet below the large flat piece of ledge standing on edge between railroad and river, 16 feet high. It is also 1,959 feet above milepost 183, and 180 feet below bridge No. 256, at the east railroad fence, directly behind T. B. M. 215, being a copper bolt in tile set 3 feet below the surface of ground.

Elevation, 198.3664 meters. 650.814 feet.

P. B. M. 227 is top of cap on iron pipe set over P. B. M. 226.

Elevation, 199.5862 meters. 654.816 feet.

P. B. M. 228 is 984 feet below Charme station, one-half mile above Mr. Valley's house, and 656 feet above the lower end of siding behind the center of Island 164, 10 feet east of the center of track, and 4 feet above grade, in face of natural ledge of rock, marked, "U. S." ⊙ P. B. M. being center of copper bolt leaded horizontally.

Elevation, 199.7900 meters. 655.485 feet.

T. B. M. 216 is 984 feet below Charme depot, and one-half mile above Mr. Valley's house, about 10 feet east of center of track, and 15 or 20 feet below P. B. M. 228, on natural ledge of rock, marked "U. □ S.," being highest point in square.

Elevation, 199.2792 meters. 653.809 feet.

T. B. M. 218 is 1¼ miles below Charme, 518 feet below milepost 185, and 492 feet above bridge No. 246, at the north edge of farm crossing, on an imbedded bowlder, 25 feet east of the center of the Chicago, Burlington and Northern Railway, being the highest point in square, marked "U. □ S."

Elevation, 198.7214 meters. 651.979 feet.

P. B. M. 229 is 3 miles below Charme, on G. L. Miller's place, now occupied by M. Sage, 257 feet below section post "30–29," 72 feet above bridge No. 243, 127 feet from the southwest corner of the house, and 95 feet from the northeast corner of barn, on the Chicago, Burlington and Northwestern Railway right of way, 18 inches east of the west fence, being copper bolt in tile 3 feet below surface of ground.

Elevation, 198.2698 meters. 650.497 feet.

P. B. M. 230 is top of cap on iron pipe set over P. B. M. 229.

Elevation, 199.4882 meters. 654.495 feet.

P. B. M. 231 is in Prairie Du Chien, in the northeastern part of the town, on the west end of St. Gabriel's Catholic Church, 19 inches from the north side, and 4 feet above ground, being a horizontal copper bolt leaded in the masonry, marked "U. S." ⊙ P. B. M.

Elevation, 202.2305 meters. 663.492 feet.

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T. B. M. 225 is in the northeastern part of Prairie Du Chien, on the east side of the street, and about 75 feet south of the St. Gabriel's Catholic Church, at the street entrance to Father Kramer's residence, on the southeast corner of the large stone step, marked "U. □ S.," being the highest point in square.

Elevation, 200.9351 meters. 659.242 feet.

T. B. M. 226 is in Prairie Du Chien, on the east end of the Chicago, Milwaukee and St. Paul Railway Bridge across the Mississippi River, on the south end of cap over the piles at end, being top of drift bolt over pile, marked with a square "□."

Elevation, 196.9116 meters. 646.041 feet.

P. B. M. 232 is in Prairie Du Chien, 2,100 feet below the east end of the Chicago, Milwaukee and St. Paul Railway Bridge across the Mississippi River at the river front of the Dousman House, on the upper end of the stone window sill of the first window below the upper entrance, being the top of a copper bolt leaded vertically, and marked U. S. ⊙ P. B. M.

Elevation, 198.4513 meters. 651.093 feet.

Old U. S. B. M. "a" is in Prairie Du Chien, on the Dousman House, on the downstream end of the downstream doorsill, being the highest point in circle, cut in stone.

Elevation, 198.4515 meters. 651.093 feet.

U. S. gauge is just above the ferry landing at the Dousman House, being a staff gauge spiked to pile.

Elevation of its zero, 190.5234 meters. 625.082 feet.

U. S. gauge is at North McGregor, at the west end of pontoon bridge, on upper side, spiked to timbering, east side of west pier, being a staff gauge.

Elevation of its zero, 190.4608 meters. 624.877 feet.

T. B. M, 227 is in North McGregor, Iowa, 131 feet below the depot, 8 feet east from the southeast corner of the small wagon road and foot bridge, and 6 feet below the floor on the river end of south abutment, being the highest point in square, marked "U. □ S."

Elevation, 195.2993 meters. 640.751 feet.

P. B. M. 233 is in North McGregor, on the north side of North street, in O. A. Bratsberg's brick store, in the water table 1 foot east from the entrance, marked "U.S." ⊙ P. B. M. being top of copper bolt leaded vertically.

Elevation, 198.5191 meters. 651.315 feet.

T. B. M. 228 is in South McGregor, Iowa, at the northwest corner of Main street and the railroad, at the sidewalk entrance to Gregor McGregor's residence, on the river end of bottom step, on a level with the sidewalk, marked "U. □ S." being the highest point in square.

Elevation, 197.7706 meters. 648.859 feet.

P. B. M. 234 is in South McGregor, Iowa, on the north side of Main street, just above the Masonic block, in brick building occupied by the "Elbling Cigar Manufactory," in stone doorsill 2 feet from the southwest corner of building, and 4.5 inches back from the front line, being top of copper bolt leaded vertically, and marked U. S. ⊙ P. B. M.

Elevation, 198.6294 meters. 651.677 feet.

P. B. M. 235 is in South McGregor, Iowa, southwest from the little park in center of the town, in the west end of the brick building owned by Mrs. J. Reynolds, and now occupied by the "Huntington Grain Firm," 23 inches south from the northwest corner and 4 feet and 10 inches above the ground, being center mark of copper bolt leaded horizontally, and marked "U. S." ⊙ P. B. M.

Elevation, 198.9796 meters. 652.826 feet.

T. B. M. 230 is about 1¾ miles below South McGregor and 55 meters above milepost 66, on the bluff side of the Chicago, Milwaukee and St. Paul Railway, 15 feet from the center, on a large prominent bowlder, marked "U. □ S.," being the highest point in square.

Elevation, 198.7837 meters. 652.183 feet.

P. B. M. 236 is about 1¾ miles below South McGregor, 275 feet above milepost 66, directly opposite Picture Rock, on the right of way of the Chicago, Milwaukee and St. Paul Railway, 35 feet east of the center of track, being copper bolt in tile, 3 feet under ground.

Elevation, 197.4441 meters. 647.788 feet.

P. B. M. 237 is top of cap on iron pipe set over P. B. M. 236, on opposite side of track, and 59 feet above T. B. M. 230.

Elevation, 198.6638 meters. 651.790 feet.

T. B. M. 231 is about one-half mile below the mouth of Wisconsin River, on the south

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abutment of bridge "K 382," on the river end on the second course of stone from the top, 1 foot from the northeast corner of stone, marked "U. □ S.," being the highest point in square.

Elevation, 197.3791 meters. 647.575 feet.

P. B. M. 238 is about 3¼ miles below South McGregor, one-half mile below the mouth of Wisconsin River, and 1,968 feet below milepost 67 of the Chicago, Milwaukee and St. Paul Railway, 45 feet west from the center of track, directly opposite the lower end of bridge "K 382," in which T. B. M. 231 is located, in the steeply inclined face of hard ledge of rock, marked U. S. ⊙ P. B. M. being the center of a copper bolt leaded horizontally.

Elevation, 199.9117 meters. 655.884 feet.

T. B. M. 232 is at the head of Island 176, 482 feet above milepost 68 (from La Crosse), on the south abutment of bridge 378 K, of the Chicago, Milwaukee and St. Paul Railway, at its east end, on the third course of stone from top, about 3 feet west from the east end of stone, and 3 inches back from the north face, marked "U. □ S.," being the highest point in square.

Elevation, 196.5430 meters. 644.832 feet.

T. B. M. 234 is behind Island 176, on the line of the Chicago, Milwaukee and St. Paul Railway, 997 feet below station "Sny McGill," 15 feet above the lower switch block of siding, and 1,115 feet below the old log house, 60 feet west from the center of track, just outside of right of way, on a 16-inch basswood tree, being top of a 6-inch wire spike in the east root.

Elevation, 197.5752 meters. 648.218 feet.

P. B. M. 239 is behind islands 176 and 178, on the line of the Chicago, Milwaukee and St. Paul Railway, 1,214 feet below the lower switch block of station "Sny McGill," and 50 feet below milepost 70 from La Crosse, just east of the west right of way fence, 30 feet from center of track, being copper bolt in tile, set 3 feet below surface of ground.

Elevation, 196.4555 meters. 644.545 feet.

P. B. M. 240 is top of cap on iron pipe set over P. B. M. 239.

Elevation, 197.6732 meters. 648.540 feet.

Old U. S. B. M. "b" is in the upper end of Clayton, Iowa, on the large stone mill at the west side of the Chicago, Milwaukee and St. Paul Railway track, on the river front of the building, at the lower window and lower end of window sill, being the top of a ring bolt, 1 inch above surface.

Elevation, 195.8445 meters. 642.540 feet.

Old U. S. B. M. is at depot, also called Old P. B. M. 27, in Clayton, Iowa, at the Chicago, Milwaukee and St. Paul Railway depot, on the top stone of foundation pier, at the northeast corner of platform, behind center of circle ⊙.

Elevation, 196.9406 meters. 646.136 feet.

P. B. M. 241 is in Clayton, Iowa, on the south side of Main street, about 656 feet back from river bank, on the southwest corner of Main and Douglas streets, on the brick building occupied by Frank Lier & Co., on east end of doorstep, marked "U. S." ⊙ P. B. M. being top of a copper bolt leaded vertically.

Elevation, 204.3073 meters. 670.306 feet.

T. B. M. 239 is about 1 mile below Clayton, 866 feet below milepost 74, 230 feet above wooden sand-hopper, on the most northerly one of two large bowlders, 19 feet west of center of track, being the highest point in square cut on top face, 1 foot from edge, marked "U. □ S."

Elevation, 198.7435 meters. 652.051 feet.

P. B. M. 242 is opposite the lower part of Island 182, nearly 3 miles below Clayton, and 141 feet below milepost 76, on the line of the Chicago, Milwaukee and St. Paul Railway, 45 feet above the highest point of heavy rock-cut waste, about in the center of long side-hill rock cut, at prominent point of bluff in the steeply inclined face of rock, 4½ feet above grade, marked "U. S." ⊙ P. B. M. being center mark in copper bolt leaded horizontally.

Elevation, 198.3219 meters. 650.668 feet.

T. B. M. 241 is in the same ledge as P. B. M. 242, about 4 feet farther down the river, and only about 2 feet above grade of track, marked "U. □ S." on face of ledge, being the highest point in square.

Elevation, 197.6006 meters. 648.302 feet.

T. B. M. 243 is about midway between Clayton and Guttenburg, on the line of the Chicago, Milwaukee and St. Paul Railway, 50 feet from the head block at the lower end of siding at Eckard, on the river side of track, on the edge of the right of way, on a 30-inch elm tree blazed, being top of spike in the root.

Elevation, 192.9816 meters. 633.147 feet.

P. B. M. 243 is one-fourth of a mile below Eckard Siding, where the Chicago, Mil-

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waukee and St. Paul Railway comes to the bluff, 215 feet above milepost 78-83, opposite the upper end of curve, 96½ feet west from center of track, 4½ feet from corner of fence, and between this fence and the highway which runs parallel with the railroad. It is also 82 feet above a cluster of butternut trees, being a copper bolt in tile set 3 feet below the surface of ground.

Elevation, 195.0697 meters. 639.998 feet.

P. B. M. 244 is top of cap on iron pipe set over P. B. M. 243.

Elevation, 196.2905 meters. 644.003 feet.

T. B. M. 245 is opposite the head of McMillan Island, on the line of the Chicago, Milwaukee and St. Paul Railway, about 1 mile below Eckard Station, 1,722 feet above milepost 79 from La Crosse, and 722 feet above the first road crossing below "Eckard," 27 feet west from center of track, on an imbedded rock, marked "U. □ S.", being the highest point in square.

Elevation, 195.9850 meters. 643.001 feet.

P. B. M. 245 is about 2⅛ miles above Guttenberg, on the line of the Chicago, Milwaukee and St. Paul Railway, midway between bridges Nos. 284 and 286, and 2,001 feet below milepost 80, at light cut, 28.5 feet east of the center of track and 2 feet west from right-of-way fence, 30 feet west of blazed 14-inch hickory tree, being a copper bolt in tile set 3 feet underground.

Elevation, 194.3142 meters. 637.519 feet.

P. B. M. 246 is top of cap on iron pipe set over P. B. M. 245.

Elevation, 195.5315 meters. 641.513 feet.

T. B. M. 247 is 328 feet below P. B. M. 246, at the lower end of bridge No. 284, on the west side of track, at the end of the first pile bent from the lower end of bridge, on an oak pile projecting about 2 feet above ground, being the top of a 6-inch wire spike, marked with a square (□).

Elevation, 193.9802 meters. 636.424 feet.

P. B. M. 247 is in Guttenberg, on the northeast corner of Herder and First streets, on the front of Joseph Huene's general store, in doorstep, 5.8 feet from the southwest corner of the building, 4½ inches from the angle of casing, and 3¼ inches back from the face of stone, being top of copper bolt leaded vertically, and marked "U. S." P. ⊙ B. M.

Elevation, 198.5974 meters. 651.572 feet.

P. B. M. 248 is in Guttenburg, Iowa, on the west side of Front street, 72.7 feet above the northwest corner of Front and Goethe streets, in the Clayton County Bank building, 8½ feet upstream from the south side of entrance way and 3.7 feet above the bottom step, marked U. S. P. ⊙ B. M. being the center mark in copper bolt leaded horizontally.

Elevation, 200.6113 meters. 658.179 feet.

T. B. M. 250 is in Guttenburg, Iowa, on the Chicago, Milwaukee and St. Paul Railway, 2,254 feet below the depot, on the upper abutment of bridge No. 274, on the river side of track, on the fourth course of stone from top, marked "U. □ S.," being the highest point in square.

Elevation, 193.9360 meters. 636.279 feet.

T. B. M. 252 is about 2¼ miles below the depot at Guttenberg, on the line of the Chicago, Milwaukee and St. Paul Railway, 213 feet above bridge No. 258, at the lower end of cut, 17 feet east of center of track, on an imbedded bowlder, marked "U. □ S.," being the highest point in square.

Elevation, 195.9731 meters. 642.962 feet.

P. B. M. 249 is about 2¼ miles below Guttenberg, about 63 feet below T. B. M. 252 on the opposite side of track, 1½ feet east of the west right-of-way fence and 18 feet from the center. It is one-half mile below where the track comes to the bluff, 150 feet above bridge No. 258, at the place where wagon road turns up into coulee and 24½ feet east of center of road, being a copper bolt in tile set 3 feet below surface.

Elevation, 194.1002 meters. 636.817 feet.

P. B. M. 250 is top of cap on iron pipe set over P. B. M. 249.

Elevation, 195.3181 meters. 640.813 feet.

T. B. M. 253 is about 3 miles below Guttenberg and 3¼ miles above the point of bluff at railroad on the north side of Turkey River, on bridge No. 236, north abutment, east end, 1 foot west from end of abutment and 6 inches north of its south face, marked "U. □ S.," being the highest point in square.

Elevation, 195.7383 meters. 642.192 feet.

T. B. M. 254 is 1¾ miles above the point of bluff at Chicago, Milwaukee and St. Paul Railway, on the north side of Turkey River, 331 feet below milepost 87 (from La Crosse), 12 feet west of center of track, on ledge of rock, marked "U. □ S.," being the highest point in square.

Elevation, 198.3202 meters. 650.663 feet.

T. B. M. 256 is 1,575 feet above the Chicago, Milwaukee and St. Paul Railway Bridge No. 212, over Turkey River, and 738 feet above the switch at Turkey River Junction,

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8 feet west from center of track, about 2 feet above grade of track, on natural ledge of rock, marked "U. □ S." on its face, being the highest point in square.

Elevation, 196.4866 meters. 644.647 feet.

P. B. M. 251 is on the line of Chicago, Milwaukee and St. Paul Railway, 1,552 feet above bridge No. 212, over Turkey River, 118 feet above the cattle guard, and 249 feet below sign "Turkey River Junction, stop," 13 feet west of center of track and 23 feet below T. B. M. 256, and about 2 feet above grade of ties, in ledge of rock, marked "U. S." ⊙ P. B. M. on its face, being the center mark in copper bolt leaded horizontally.

Elevation, 197.0112 meters. 646.368 feet.

T. B. M. 257 is on the line of the Chicago, Milwaukee and St. Paul Railway, at Turkey River, on the upper stone pier of the bridge No. 212, on the west side of the track, 9 feet from the west end of the pier and 7 inches back from its north face, being the highest point in square, marked "U. □ S."

Elevation, 193.9888 meters. 636.452 feet.

P. B. M. 252 is at Turkey River Junction, Iowa, 1,148 feet above the depot, at the upper end of the Chicago, Milwaukee and St. Paul Railway Bridge No. 212, over Turkey River, on the west end of the pier, carrying also T. B. M. 257, 14 inches east from extreme point of rounding capstone, marked "U. S." ⊙ P. B. M. being top of a copper bolt leaded vertically.

Elevation, 193.9924 meters. 636.464 feet.

T. B. M. 258 is on the line of the Chicago, Milwaukee and St. Paul Railway, 1,689 feet below the depot at Turkey River Juunction, 1,660 feet above milepost 90, and 50 feet above the very large and prominent bowlder on the west side of the track, also 328 feet above the farm house at point of woods on river side of track, 15 feet west of center, on a ledge of rock, marked "U. □ S.," being the highest point in square.

Elevation, 196.0106 meters. 643.085 feet.

P. B. M. 253 is on the line of Chicago, Milwaukee and St. Paul Railway track, 2⅝ miles above Buena Vista, Iowa, 53 feet below the center of bridge 204 K, on right of way of the Chicago, Milwaukee and St. Paul Railway, at fence on the bluff side, 36 feet from center of track, being a copper bolt in tile set 3 feet below surface of ground.

Elevation, 194.1789 meters. 637.076 feet.

P. B. M. 254 is top of cap on iron pipe set over P. B. M. 253, standing about a foot above ground.

Elevation, 195.3981 meters. 641.076 feet.

T. B. M. 262 is opposite the foot of Island 196, 1 mile above Buena Vista and 2,986 feet above milepost 93, and 15 feet toward the bluff from the center of the Chicago, Milwaukee and St. Paul Railway track, on the upper one of three large, prominent pieces of rock lying but a few feet from each other, marked "U. □ S.," being the highest point in square.

Elevation, 196.7898 meters. 645.642 feet.

T. B. M. 264 is in Buena Vista, Iowa, 82 feet above the depot and 35 feet above the road crossing, on the bluff side of the track, 9 feet from the center, about 2½ feet above grade, on a hard ledge of rock, marked "U. □ S.," being the highest point in square.

Elevation, 197.2508 meters. 647.154 feet.

P. B. M. 255 is in Buena Vista, at the southeast corner of R. & E. Meuth's general store, 6 inches from the south face and 4.3 feet above ground, in wall marked "U. S." ⊙ P. B. M. being the center mark in copper bolt leaded horizontally.

Elevation, 197.3481 meters. 647.473 feet.

T. B. M. 265 is three-quarters of a mile below Buena Vista, Iowa, 1,840 feet below milepost 94-67, and 590 feet below bridge No. 194, on the bluff side of track, 15 feet from center, on an embedded bowlder, marked "U. □ S.," being the highest point in square.

Elevation, 197.5448 meters. 648.119 feet.

T. B. M. 267 is 2 miles below Buena Vista, 1,575 feet below section post 11-12, 1,411 feet below Bridge 188 K, and 775 feet above Dry Hollow bridge (186 K), on the line of the Chicago, Milwaukee and St. Paul Railway, 10 feet south from center, on the ledge of rock, marked "U. □ S., being the highest point in square.

Elevation, 197.4015 meters. 647.649 feet.

P. B. M. 256 is 1¼ miles above Waupeton, Iowa, 1,739 feet above milepost 96-65, 122 feet above bridge 186 K, over Dry Hollow, on the bluff side of track, 16.5 feet from center, just outside of the right-of-way fence, being a copper bolt in tile set 3 feet underground.

Elevation, 196.2087 meters. 643.735 feet.

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P. B. M. 257 is top of cap on iron pipe set over P. B. M. 256.
Elevation, 197.4278 meters. 647.735 feet.

T. B.M. 269 is 1¼ miles above Waupeton, 593 feet below milepost 96-65, 377 feet above bridge 180 K, and just below a prominent ledge of white rock on the bluff side of track, 10 feet from center, also 146 meters below bridge No. 182, 2 feet above grade of track, on ledge of rock, marked "U. □ S,," being the highest point in square.
Elevation, 197.9319 meters. 649.389 feet.

T. B. M. 270 is 1,171 feet above the depot at Waupeton, 420 feet below milepost 97-64, 262 feet above bridge No. 174, on bluff side of track, 10 feet from center, on the natural ledge of rock, about level with the grade, marked "U. □ S." on its face, being the highest point in square.
Elevation, 196.9757 meters. 646.252 feet.

P. B. M. 258 is 853 feet below Waupeton, 612 feet below bridge No. 172, on the north face of bluff, at the point where it begins to curve to the south, 36 feet south from the center of the Chicago, Milwaukee and St. Paul Railway track and 2 feet south from the south right-of-way fence, being a copper bolt in tile, set 3 feet underground.
Elevation, 193.7875 meters. 635.791 feet.

P. B. M. 259 is top of cap on iron pipe set over P. B. M. 258.
Elevation, 195.0032 meters. 639.780 feet.

T. B. M. 273, 2¼ miles below Waupeton and 1¼ miles below Cameron, Iowa, on the line of the Chicago, Milwaukee and St. Paul Railway, 2,053 feet above milepost 100-61, 100 feet, more or less, below the very large and conspicuous piece of ledge covered with vines lying on the bluff side of right of way, on a bowlder marked "U. □ S.," being the highest point in square.
Elevation, 197.0191 meters. 646.394 feet.

P. B. M. 260 is at Finley Landing, on the line of the Chicago, Milwaukee and St. Paul Railway, 649 feet below milepost 101-60 and 180 feet above bridge No. 162 on the right of way, 2 feet from the south fence and 38 feet from center of track, being a copper bolt in tile set 3 feet underground.
Elevation, 194.7088 meters. 638.814 feet.

P. B. M. 261 is top of cap on iron pipe set over P. B. M. 260.
Elevation, 195.9285 meters. 642.816 feet.

P. B. M. 262 is in front of Island 207, 919 feet above milepost 102-59, and 79 feet above section post 10-11, on the west abutment of bridge No. 156, at its north end, on the fourth stone step from top, and 3 inches from the end face of the third step, 9 inches back from the east face, marked "U. S." ⊙ P. B. M. being top of copper bolt leaded vertically.
Elevation, 193.7183 meters. 635.564 feet.

T. B. M. 277 is at Frenchtown Landing one-fourth mile above milepost 104-57, 115 feet below bridge No. 148, and 25 feet above the end of platform at entrance to picnic grounds, 20 feet south from center of track, on a flat rock, imbedded, marked "U. □ S.," being the highest point in square.
Elevation, 193.2228 meters. 633.939 feet.

P. B. M. 263 is at Frenchtown Landing, 35 feet above T. B. M. 277, 1,335 feet above milepost 104-57, 80 feet below bridge No. 148, and 60 feet above platform on side of railroad, and at the entrance to picnic grounds, on the east side of coulee, 38 feet south from center of track, on the right of way, 1¼ feet from the south limit, under the extreme northwest point of tableland forming the picnic ground, being a copper bolt in tile set 3 feet underground.
Elevation, 192.2713 meters. 630.817 feet.

P. B. M. 264 is top of cap on iron pipe set over P. B. M. 263.
Elevation, 193.4906 meters. 634.817 feet.

Old U. S. P. B. M. on stone step, No. 30, is at Specht Ferry, Iowa, on the upper stone doorstep to Specht's stone house, downstream end, front edge, marked "⊙," being the highest point in the upper portion of circle.
Elevation, 193.6650 meters. 635.390 feet.

Old U. S. B. M. "a" is at Specht Ferry, Iowa, at the northeast corner of Specht's house, on the water table, but a few inches above the corner, marked "B. ⊙ M.," being the highest point on front segment.
Elevation, 193.8100 meters. 635.865 feet.

P. B. M. 265 is at Specht Ferry, Iowa, 354 feet below center of the Chicago, Milwaukee and St. Paul Railway depot, 164 feet below bridge No. 140, 174 feet below the lower side of stone milk house, 1 foot above fence forming the west side of the railroad cattle pen, on the bluff side of track, 37.4 feet from center, being copper bolt in tile, set about 3 feet under the ground.
Elevation, 192.4329 meters. 631.347 feet.

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P. B. M. 266 is top of cap on iron pipe set over P. B. M. 265.
Elevation, 193.6515 meters. 635.345 feet.
T. B. M. 279 is one-third mile below the Chicago, Milwaukee and St. Paul Railway depot at Specht Ferry, one-half mile above milepost 106-55, and 82 feet below a large bare ledge of rock inclining at an angle of about 45 degrees with the horizon, on bluff side of track, 10 feet from the center, on the natural ledge of rock, marked "U. □ S.," being the highest point in square.
Elevation, 194.4108 meters. 637.836 feet.
T. B. M. 280 is 1¼ miles below Specht Ferry, Iowa, at Parsons Bar, in cove or borrow pit at the lower end, and base of heavy side-hill cut, about 300 feet, more or less, above bridge No. 134, where the railroad leaves the river bank and enters woods, on natural ledge of hard rock, about 50 feet from track center, marked "U. □ S.," being the highest point in the square.
Elevation, 194.6129 meters. 638.499 feet.
P. B. M. 267 is 1¼ miles below Specht Ferry, at Parsons Bar, on the extreme point of bluff, between rock quarry where T. B. M. 280 is located and railroad bridge No. 134, 25.5 feet south from center of track, being a copper bolt in tile set 3 feet underground.
Elevation, 191.8716 meters. 629.506 feet.
P. B. M. 268 is top of cap on iron pipe set over P. B. M. 267.
Elevation, 193.0946 meters. 633.518 feet.
P. B. M. 269 is 2¼ miles above the Little Maquoketa River, on the line of the Chicago, Milwaukee and St. Paul Railway and 3⅛ miles below Specht Ferry, 912 feet below milepost 108-53, and opposite the lower end of bridge No. 128, over Leisures Creek, 49 feet east from center of track, on the right of way in the corner of fence formed by main fence and wing fence to bridge No. 128, in slope of bluff, being a copper bolt in tile set about 3 feet underground.
Elevation, 194.4677 meters. 638.023 feet.
P. B. M. 270 is top of cap on iron pipe set over P. B. M. 269.
Elevation, 195.6946 meters. 642.048 feet.
T. B. M. 283 is 1½ miles above the Little Maquoketa Bridge, on the line of the Chicago, Milwaukee and St. Paul Railway, two-thirds of a mile above Zollicoffer Lake and 1,076 feet above milepost 109-52, 12 feet west of track, on a large flat rock inside of bank, inclining perhaps 30 degrees to the horizon, marked "U. □ S.," being the highest point in square,
Elevation, 194.0096 meters. 636.520 feet.
P. B. M. 271 is on the right of way of the Chicago, Milwaukee and St. Paul Railway track, 531 feet below the south end of bridge 124 K, over the Little Maquoketa River, very closely on line produced of the east side of said bridge, 6¾ miles above Dubuque, and three-fourths of a mile above "Edmore" siding, on the west side of track, 2 feet from the fence, opposite the center of curve in railroad line, being copper bolt in tile set about 3 feet below surface of ground.
Elevation, 192.7035 meters. 632.235 feet.
P. B. M. 272 is top of cap on iron pipe set over P. B. M. 271.
Elevation, 193.9224 meters. 636.234 feet.
T. B. M. 287 is 2.3 miles above Eagle Point, 1,569 feet below milepost 112-49, 1,161 feet above bridge 120 K, 377 feet below bridge 122 K, and 836 feet below the small railroad platform in front of Mr. Cushing's house, 6 feet west from the center of track, on the upper end of capstone of small stone culvert, marked "U. □ S." being the highest point in square.
Elevation, 192.4274 meters. 631.329 feet.
P. B. M. 273 is 58 feet south of the small stone culvert on which T. B. M. 287 is located, 2.3 miles above Eagle Point, 436 feet below bridge 122 K, and 896 feet below the railroad platform in front of Mr. James Cushing's house, 23.3 feet east from the center of track, on right of way, being copper bolt in tile set 3 feet below the surface of ground.
Elevation, 191.4759 meters. 628.207 feet.
P. B. M. 274 is top of cap on iron pipe set over P. B. M. 273.
Elevation, 192.6934 meters. 632.202 feet.
T. B. M. 289 is about 1¼ miles above Eagle Point, one-fourth mile below milepost 113-48, midway between two small wooden box culverts, 20 feet west of center of track on natural ledge, marked "U. □ S.," being highest point in square.
Elevation, 194.5426 meters. 638.269 feet.
Old U. S. B. M. 23 is at Eagle Point, above Dubuque, at the prominent point of river bank covered with large rock, above the ferry landing, on the southwest portion of the very large triangular-shaped rock lying at the water's edge, being the highest point in the bottom part of the letter "B" cut on the rock.
Elevation, 187.2810 meters. 614.444 feet.
T. B. M. 291 is in Eagle Point, Dubuque, on the Dubuque Woodenware Company's drying house, east of the railroad tracks, on top of the stone foundation, 10 feet from

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the west side, on the lower side of building, marked "U. □ S." being the highest point in square.

Elevation, 191.6503 meters. 628.780 feet.

P. B. M. 275 is in Eagle Point, Dubuque, in the main building of the Dubuque Woodenware Company, on the river bank, in the foundation on the south side, 1.8 feet from the west corner and 2.1 feet above the ground, marked "U. S." ⊙ P. B. M. being the center mark in copper bolt leaded horizontally.

Elevation, 190.7397 meters. 625.792 feet.

P. B. M. 276 is at Eagle Point, one-fifth mile below the Dubuque Woodenware Company's works, on the line of the Chicago, Milwaukee and St. Paul Railway, 2,181 feet above milepost 115–46, 394 feet above bridge No. 114, and 267 feet below bridge No. 114½, over sewer, on the upper end of mound built up from earth excavation from the opposite side of the track, 1½ feet west from the east fence and 13.6 feet from center of track, being a copper bolt in tile set 3 feet below surface of ground.

Elevation, 191.3923 meters. 627.933 feet.

P. B. M. 277 is top of cap on iron pipe set over P. B. M. 276.

Elevation, 192.6098 meters. 631.928 feet.

T. B. M. 293 is the upper part of Dubuque, on the line of the Chicago, Milwaukee and St. Paul Railway, at the northwest corner of their freight-car repair shop, on the southwest corner of the foundation stone, marked "U. □ S.", being the highest point in square.

Elevation, 192.3265 meters. 630.998 feet.

T. B. M. 294 is in Dubuque, about one-half mile below the Chicago, Milwaukee and St. Paul Railway shops, at the southeast corner of the Iowa Coffin Company's warehouse, on top of the foundation stone, being the highest point in square.

Elevation, 191.8427 meters. 629.411 feet.

P. B. M. 278 is on the same building as T. B. M. 294, at the northwest corner of Fifteenth and Pine streets, Dubuque, Iowa, on the south side of the Iowa Coffin Company's warehouse, on the west end of the first doorstep from Pine street, marked "U.S." ⊙ P.B.M., being top of a copper bolt leaded vertically.

Elevation, 191.8810 meters. 629.536 feet.

T. B. M. 295 is in Dubuque, Iowa, on southwest corner of Elm and Ninth streets, on the end of the curb abutting against the northeast corner of the Chicago, St. Paul and Kansas City freight house, marked "U. □ S.," being the highest point in square.

Elevation, 191.2479 meters. 627.459 feet.

P. B. M. 279 is in Dubuque, Iowa, at the northeast corner of the United States post-office building, 10 inches south of the north corner and 3 feet above the stone paving, marked "U. S." ⊙ P. B. M., being the center mark of a copper bolt leaded horizontally.

Elevation, 202.6137 meters. 664.749 feet.

City B. M. is on the Julien House, in Dubuque, Iowa, on the north side of Second street, at the east door of the older part of the Julien House, on the east end of doorstep, which is about 32 feet west of Iowa street, being the highest point in square. Elevation city datum, 24.455 feet.

Elevation, 192.7955 meters. 632.537 feet.

The Dubuque city engineer gives:

	Feet.
Low water 1854 = Dubuque city datum, elevation	000.00
Low water 1864 = Dubuque city datum, elevation	— 3.33
High water 1870 = Dubuque city datum, elevation	18.5
High water 1880 = Dubuque city datum, elevation	19.5

City B. M. is on Jess's store, in Dubuque, on the southwest corner of First and Main streets, near the southeast corner of Jess's store, on the north end of doorstep, being the highest point in square. Elevation above city datum, 20.893 feet.

Elevation, 191.6827 meters. 628.886 feet.

T. B. M. 296 is in Dubuque, Iowa, on the north side of Fourth street, opposite the Chicago, Milwaukee and St. Paul Railway depot, on the Page House, 26½ inches east of the southeast corner of the building, on water table 6 inches in front of the west window, marked "U. □ S.," being the highest point in the square.

Elevation, 191.5050 meters. 628.303 feet.

P. B. M. 280 is in Dubuque, Iowa, on the west end and first pier of the Illinois Central Railway Bridge across the Mississippi River, at the upper end of pier, near its west edge and about in the center of the bridge-seat stone, marked "U. S." ⊙ P. B. M., being top of copper bolt leaded vertically.

Elevation, 194.4662 meters. 638.018 feet.

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United States gauge is at Dubuque, above the draw pier on the breakwater cribwork on the inside of the east timbering, being a staff gauge.
Elevation gauge zero, 184.2801 meters. 604.599 feet.
Old U. S. B. M. "a" is in East Dubuque, Ill., on the west abutment of the Jack Knife Draw of the Illinois Central Railway over the Chicago, Burlington and Northern Railway on its south end, on the southeast corner of top-stone, marked "B.⊙ M.," being the highest point of square within the old circle.
Elevation, 193.5917 meters. 635.149 feet.
Old U. S. B. M. "b" is in East Dubuque, east of the Chicago, Burlington and Northern Railway track, under the end of the Dubuque highway bridge across the Mississippi, on the upstream foundation stone supporting the triangular truss of said highway bridge, on the upstream corner of stone, marked "B.⊙ M.," being the highest point of square within the old circle.
Elevation, 193.3685 meters. 634.417 feet.
T. B. M. 297 is in Dubuque, Iowa, on the Illinois Central depot, at its north end, about in the center of the east side of the tower, in water table, being the highest point in square.
Elevation, 191.4797 meters. 628.220 feet.
Old U. S. B. M. "a" is in Dubuque, Iowa, at the river front below the harbor, on the Diamond Joe store, on the upstream end of the upstream stone door-sill, marked "◻", being the highest point of circle in square.
Elevation, 191.2175 meters. 627.360 feet.
Old U. S. B. M. "b" is in Dubuque, on the river front below the harbor, on the southeast corner of Houser & Linnehan's boat store, 1¼ feet above the corner, on the water table, in the center of buttress, marked "⊙", being the highest point of circle in circle.
Elevation, 190.8709 meters. 626.222 feet.
P. B. M. 281 is in the southern extremity of Dubuque, at the bluff, one-eighth mile below the sawmill, directly opposite the end of runway to mill, 305 feet above the head block of the sawmill siding, 26 feet west from center of siding, in a recess in the face of rock bluff, marked U. S. ⊙ P. B. M. being the center mark in a copper bolt leaded horizontally.
Elevation, 192.7453 meters. 632.372 feet.
T. B. M. 299 is about 1 mile below Dubuque, at point of bluff on the lower side of the ravine through which the Illinois Central Railway passes from the river, 623 feet below the bridge on the Chicago, Milwaukee and St. Paul Railway track, 164 feet above the house owned by R. Smith and 98 feet west of the center of the Chicago, Milwaukee and St. Paul Railway track, on top of a large, flat rock, marked "U. ◻ S.", being the highest point in square.
Elevation, 192.2320 meters. 630.688 feet.
P. B. M. 282 is about 1 mile below Dubuque, at point of bluff on the south side of Rugdale Hollow, through which the Illinois Central Railway passes from the river, about 36 feet from T. B. M. 299, 623 feet from the Chicago, Milwaukee and St. Paul Railway Bridge, 180 feet above a house owned by R. Smith, 131 feet west from center of track, 43 feet northwest from a blazed elm on the upper side of a large flat rock, being a copper bolt in tile set about 3 feet underground.
Elevation, 192.0054 meters. 629.945 feet.
P. B. M. 283 is top of cap on iron pipe set over P. B. M. 282.
Elevation, 193.2244 meters. 633.944 feet.
T. B. M. 301 is about 3¼ miles below Dubuque, 660 feet below milepost 121–40, 370 feet above the upper head block of siding at "Cattes" and 295 feet below Creston Crossing, on the lower side of coulée, 25 feet west from center of track, on natural ledge of rock, marked "U. ◻ S.", being the highest point in square.
Elevation, 194.0671 meters. 636.709 feet.
P. B. M. 284 is on the upper side of coulee, where T. B. M. 301 is located, 344 feet below milepost 121–40, and 669 feet above the upper headblock of switch to Cattes Siding, 43 feet from center of track on the bluff side in fence corner by gate, being a copper bolt in tile set 3 feet underground.
Elevation, 192.9158 meters. 632.932 feet.
P. B. M. 285 is top of cap on iron pipe set over P. B. M. 284.
Elevation, 194.1350 meters. 636.932 feet.
T. B. M. 302 is opposite the foot of Island 228, 72 feet above the lower head block of switch at Cattes Siding, 15 feet west from center of side track, in natural ledge of rock, marked "U. ◻ S.," being the highest point in square.
Elevation, 194.1949 meters. 637.128 feet.
T. B. M. 303 is about 1¼ miles above the head of Nine Mile Island, on the line of the Chicago, Milwaukee and St Paul Railway, directly opposite milepost 122–39, on bluff side, 9 feet from center, on natural ledge of rock, marked "U. ◻ S.," being the highest point in square.
Elevation, 193.5329 meters. 634.956 feet.

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T. B. M. 304 is about 5 miles below Dubuque and a half mile above the head of Nine Mile Island, on the south abutment of bridge No. 86, river end, on the second course of stone below the bridge seat, on its northeast corner, marked "U. □ S.," being the highest point in square.

Elevation, 191.1727 meters. 627.213 feet.

Old U. S. B. M. 24 is about 5 miles below Dubuque and a half mile above Nine Mile Island, on the south abutment of bridge No. 86, where T. M. B. 304 is located, on the river end of abutment, lowest course of stone, on the northeast corner of step, now marked "□," being the highest point in square.

Elevation, 186.2127 meters. 610.940 feet.

P. B. M. 286 is 6 miles below Dubuque, on the line of the Chicago, Milwaukee and St. Paul Railway, at the Shawondasce Club Grounds Station, 76 feet below the south end of the platform and 86 feet above the boundary fence between Paul Eiffer's and Frank Noel's lands, on the west side of track, 47.1 feet from the center, being a copper bolt in tile set about 3 feet underground.

Elevation, 189.7878 meters. 622.669 feet.

P. B. M. 287 is top of cap on iron pipe set over P. B. M. 286.

Elevation, 191.0070 meters. 626.669 feet.

T. B. M. 307 is behind Ninemile Island, about one-half mile below Massey Station, on the Chicago, Milwaukee and St. Paul Railway, 1,970 feet below milepost 124–37, 449 feet above bridge 80 K and 170 feet below bridge 82 K, about 30 feet west of the center of track, in the base of a black-oak tree, being top of large spike.

Elevation, 191.8960 meters 629.586 feet.

T. B. M. 308 is about 1⅜ miles below Massey Station, Chicago, Milwaukee and St. Paul Railway, on the south abutment of bridge 78 K, west end, on the second course of stone from top, on its southwest corner, marked "U. □ S.," being the highest point in square.

Elevation, 191.1008 meters. 626.977 feet.

P. B. M. 288 is opposite the foot of Ninemile Island, at the woodyard, 20 feet below the road leading from woodyard across the Chicago, Milwaukee and St. Paul Railway track up the bluff, 36 feet east from center of track and 2 feet west of the east right-of-way fence, being a copper bolt in tile set 3 feet underground.

Elevation, 190.0912 meters. 623.664 feet.

P. B. M. 289 is top of cap on iron pipe set over P. B. M. 288.

Elevation, 191.3102 meters. 627.664 feet.

T. B. M. 311 is 1 mile below P. B. M.'s 288 and 289, on the south abutment of bridge No. 76, west end, on the second course of stone from top, marked "U. □ S.," being highest point in square.

Elevation, 192.4623 meters. 631.444 feet.

T. B. M. 312 is opposite the head of Island 235, 1,270 feet above milepost 128–33, 410 feet below bridge 72 K, at Snyder's woodyard, 12 feet west of center of track, on the lower end of a very large inclined rock at a rocky point, marked "U. □ S.," being the highest point in square.

Elevation, 192.4424 meters. 631.378 feet.

P. B. M. 290 is 285 feet above T. B. M. 312, about 3 miles above Gordon Ferry, 125 feet below center of bridge 72 K, opposite the head of Island 235, 43 feet west of the center of the Chicago, Milwaukee and St. Paul Railway track, on the right of way, at the railroad fence, being copper bolt in tile set 3 feet underground.

Elevation, 190.2858 meters. 624.303 feet.

P. B. M. 291 is top of cap on iron pipe set over P. B. M. 290.

Elevation, 191.5059 meters. 628.306 feet.

T. B. M. 314 is about 1 mile above Gordon Ferry, Iowa, on the line of the Chicago, Milwaukee and St. Paul Railway, 52 feet below sign "Gordon's Ferry, One Mile," on the south abutment, river end of bridge 68 K, just above ruins of the large stone house, on the fourth course of stone from top, on the center of the north end of the inner stone, marked "U. □ S.," being the highest point in square.

Elevation, 188.6916 meters. 619.072 feet.

P. B. M. 292 is about 1 mile above Gordons Ferry, 345 feet above Tete du Mort Creek, 215 feet below bridge No. 68, on which T. B. M. 314 is located, and 75 feet below the old stone building, 27 feet west from center of the Chicago, Milwaukee and St. Paul Railway track, being a copper bolt in tile set 3 feet under ground.

Elevation, 189.1548 meters. 620.592 feet.

P. B. M. 293 is top of cap on iron pipe set over P. B. M. 292.

Elevation, 190.3750 meters. 624.595 feet.

T. B. M. 315 is about one-half mile above Gordons Ferry, 572 meters below bridge No. 66, and 1,213 feet above the water tank, midway between two projecting points of bluff 12 feet west from center of track, and 1½ feet above grade on natural ledge of rock, marked "U. □ S.," being the highest point in square.

Elevation, 192.6218 meters. 631.967 feet.

P. B. M 294 is at Gordons Ferry, 250 feet below bridge No. 64, 215 feet below

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depot, 125 feet above the lower headblock of siding, 45 feet below the lower side of stock yard, and 34 feet from center of main track on bluff side, being a copper bolt in tile set 3 feet under ground.

Elevation, 193.3034 meters. 634.203 feet.

P. B. M. 295 is top of cap on iron pipe set over P. B. M. 294.

Elevation, 194.5177 meters. 638.187 feet.

T. B. M. 318 is 1¼ miles below Gordons Ferry, Iowa, on the line of the Chicago, Milwaukee and St. Paul Railway, 396 feet below milepost 132–29, and 18 feet west from center of track, one-half foot above surface of ground, on a flat rock, marked "U. □ S.," being the highest point in square.

Elevation, 192.3454 meters. 631.060 feet.

P. B. M. 296 is 1¼ miles below Gordons Ferry, about one-third mile below milepost 132–29, on a low ridge at the upper side of coulee, 49 feet west from the center of the Chicago, Milwaukee and St. Paul Railway track, on the right of way, at the west fence, being a copper bolt in tile set 3 feet under ground.

Elevation, 191.1334 meters. 627.084 feet.

P. B. M. 297 is top of cap on iron pipe set over P. B. M. 296.

Elevation, 192.3561 meters. 631.095 feet.

T. B. M. 321 is at the point of bluff at the head of Bellevue Slough, at the lower end of cut, in front of house owned by A. M. Brown, and 15 feet below the path running to this house, 125 feet above bridge No. 56, at the upper side of cattle guard, 12 feet west of the center of the track, on natural ledge of rock, marked "U. □ S.," being the highest point in square.

Elevation, 191.2552 meters. 627.483 feet.

P. B. M. 298 is on the opposite side of the track from T. B. M. 321, at the head of Bellevue Slough, three-fourths of a mile above Smiths Station, 110 feet above bridge No. 56, 55 feet below the lower line of A. M. Brown's house, 12 feet below the cattle guard, on the river side of track, 16 feet from center, on small bench of ground between cattle guard and gate leading down to river, being a copper bolt in tile.

Elevation, 189.5907 meters. 622.022 feet.

P. B. M. 299 is top of cap on iron pipe set over P. B. M. 298.

Elevation, 190.8047 meters. 626.005 feet.

T. B. M. 323 is behind Bellevue Slough, 1¼ miles below Smiths Station, on the Chicago, Milwaukee and St. Paul Railway, 148 feet below a stone culvert about in center of short, heavy fill, at the lower end of the long curve, 60 feet east from center of track, several feet outside of the right of way. It is also 1,902 feet above bridge No. 50, on a 10-inch oak tree, being a spike in its root.

Elevation, 191.6164 meters. 628.668 feet.

P. B. M. 300 is behind Bellevue Slough, 262 feet from low-water edge, 1¼ miles below Smiths, and 3 miles above North Bellevue, 1,900 feet above bridge 50 K, and 150 feet below the stone culvert on the right of way at the east fence, but a few feet below T. B. M. 323, being a copper bolt in tile set 3 feet under ground.

Elevation, 190.8255 meters. 626.074 feet.

P. B. M. 301 is top of cap on iron pipe set over P. B. M. 300.

Elevation, 192.0371 meters. 630.049 feet.

P. B. M. 302 is 1 mile above North Bellevue, on the line of the Chicago, Milwaukee and St. Paul Railway, and 1,279 feet below milepost 138–23, in the north abutment, east end of bridge 48 K, on the third course of stone from top, marked "U. S." ⊙ P. B. M. being the center of copper bolt leaded vertically.

Elevation, 197.0180 meters. 646.390 feet.

P. B. M. 303 is 1 mile above North Bellevue, 40 feet back from high-water line on river bank and 45 feet north of bank of creek which is crossed by Chicago, Milwaukee and St. Paul Railway Bridge 48 K, where P. B. M. 302 is located, about 984 feet from said railroad, and about 410 feet below large stone arch culvert under wagon road, and 36 feet south from another wagon road winding around the south point of bluff, being a copper bolt in tile set 3 feet underground.

Elevation, 186.4228 meters. 611.629 feet.

P. B. M. 304 is top of cap on iron pipe set over P. B. M. 303.

Elevation, 187.6338 meters. 615.602 feet.

T.B.M.325 is in Bellevue, on the west side of Second street, in oak grove, at the upper part of the town, just above lot of Wm. Coppas, and 7 feet west of the sidewalk, being a large spike in the base of a large oak tree.

Elevation, 196.2102 meters. 643.740 feet.

P. B. M. 305 is in the upper part of Bellevue, on the west line of Front street, in the northeast corner of lot owned by Mrs. Booth, 2 feet south from the north side of lot and south side of a street, being a copper bolt in tile set 3 feet under ground.

Elevation, 194.6941 meters. 638.766 feet.

P. B. M. 306 is top of cap on iron pipe set over P. B. M. 305.

Elevation, 195.9122 meters. 632.762 feet.

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P. B. M. 307 is in Bellevue, on the southeast corner of Court and Second streets, on the front of the stone store owned by John Baumann, on the lower end of water table 2¼ feet above the south corner, marked "U. S." ⊙ P. B. M. being top of copper bolt leaded vertically.

Elevation, 194.8144 meters. 639.161 feet.

Old U. S. B. M. is in Bellevue, at river shore, on Killburn & Co.'s warehouse, on projecting stone at the east end of the south wall, just below the iron bolt plate, being the highest point in circle cut in stone.

Elevation, 188.0286 meters. 616.897 feet.

T. B. M. 326 is in the south end of Bellevue, on the line of the Chicago, Milwaukee and St. Paul Railway, on bridge 44 K, over Mill Creek, between the flour mill and sawmill, on the north pier at its east end, marked "U. □ S.", being the highest point in square.

Elevation, 191.4794 meters. 628.219 feet.

P. B. M. 308 is in the lower end of Bellevue, Iowa, on the river bank, in first building above the sawmill, a two-story stone store, owned by M. G. Heiler, at its west front, second door from north end, marked "U. ⊙ S.," being top of a copper bolt leaded vertically.

Elevation, 192.2421 meters. 630.721 feet.

P. B. M. 309 is 2 miles below Bellevue, 558 feet above the center of the Chicago, Milwaukee and St. Paul Railway Bridge 42 K, over Duck Creek, 148 feet above milepost 142–19, at upper side of highway crossing, at the south side of fence running to cattle guard, and 20 feet east from center of track, being a copper bolt in tile set 3 feet under ground.

Elevation, 190.5064 meters. 625.027 feet.

P. B. M. 310 is top of cap on iron pipe set over P. B. M. 309.

Elevation, 191.7190 meters. 629.005 feet.

T. B. M. 329 is one-fourth mile below bridge 42 K, one-third mile below milepost 142–19, on line of the Chicago, Milwaukee and St. Paul Railway, and 279 feet above sluiceway under track, 12 feet west from center of track, on the west side of ditch on natural outcropping of ledge of rock, marked "U. □ S.," being the highest point in square.

Elevation, 190.6745 meters. 625.578 feet.

T. B. M. 331 is 3¼ miles below Bellevue, on the line of the Chicago, Milwaukee and St. Paul Railway track, 250 feet above C. A. Harrington's house, on the southwest corner of the stone culvert, 3 feet above the south side and 3 inches back from the west end, marked "U. □ S.," being the highest point in square.

Elevation, 189.0567 meters. 620.270 feet.

P. B. M. 311 is 3¼ miles below Bellevue, on the line of the Chicago, Milwaukee and St. Paul Railway, 705 feet below the stone culvert on which T. B. M. 331 is located, 177 feet below the lower side of C. A. Harrington's stone barn, 40 feet above the wooden drain under the track, at the lower end of small cut, 33 feet east from center of track, and 1½ feet west from the east right of way fence, being a copper bolt in tile set about 3 feet under ground.

Elevation, 187.6006 meters. 615.493 feet.

P. B. M. 312 is top of cap on iron pipe set over P. B. M. 311.

Elevation 188.8174 meters. 619.485 feet.

T. B. M. 332 is on the north bank of Island 250, on the south side of slough behind a small tow-head, two-thirds mile below the head of the island, on a large leaning elm, blazed, being top of spike in root.

Elevation, 184.5016 meters. 605.326 feet.

T. B. M. 333 is on the lower side of slough, at the south end of Island 250, at Golden's woodyard, 98 feet northwest of the northwest corner of Mr. Golden's log house, on a 20-inch ash tree on top of bank, the nearest to the river of a row of four ash trees, being spike in root.

Elevation, 186.1625 meters. 610.775 feet.

P. B. M. 313 is at the third tree from the river of the same row of trees where T. B. M. 333 is located, about 5½ miles below Bellevue, on the south side of slough at the foot of Island 250, 88 feet from the northwest corner of Mr. Golden's log house, being top of copper bolt in tile set about 3 feet under ground.

Elevation, 185.5771 meters. 608.854 feet.

P. B. M. 314 is top of cap on iron pipe set over P. B. M. 313.

Elevation, 186.7874 meters. 612.825 feet.

P. B. M. 315 is opposite Island 253, one-third mile below the log house at Golden's woodyard, 56 feet back from top of bank, and 2 feet below the fence on the lower side of clearing and upper side of woods, which runs at about right angles to the river bank, 8 feet above a 10-inch ash tree, blazed, facing the bench, being a copper bolt in tile set 3 feet under ground.

Elevation, 185.1865 meters. 607.573 feet.

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P. B. M. 316 is top of cap on iron pipe set over P. B. M. 315.
Elevation, 186.3949 meters. 611.537 feet.

T. B. M. 337 is on left bank, opposite the foot of Island 254, at Harris Landing, at foot of sand bluff, 50 feet above the road leading up the bank to L. T. Green's house, in the south root of the large elm, being top of spike.
Elevation, 185.2787 meters. 607.875 feet.

P. B. M. 317 is at Harris Landing, Illinois, on land owned by Jackson Harris, on the east side of highway on top of the sand bluff, 184 feet above the house now occupied by L. T. Green, in the northwest corner of small field above the dooryard, very close to roadside fence, being top of copper bolt in tile set 3 feet under ground.
Elevation, 192.3004 meters. 630.912 feet.

P. B. M. 318 is top of cap on iron pipe set over P. B. M. 317.
Elevation, 193.5094 meters. 634.879 feet.

P. B. M. 319 is at Harris Landing, Ill., on Jackson Harris's farm, now occupied by L. T. Green, 207 feet below his house, in the roadside, very close to the east fence, 3 feet below the fence at south side of door yard, at the north end of the lilac hedge, being copper bolt in tile set about 3 feet underground.
Elevation, 192.6446 meters. 632.042 feet.

P. B. M. 320 is top of cap on iron pipe set over P. B. M. 319.
Elevation, 193.8631 meters. 636.040 feet.

P. B. M. 321 is about 1¼ miles below Harris Landing and 1¼ miles above Island 256, back from the top of sand bluff, under the east fence of highway, 31 feet southeast from cattle pen, under wagon road leading from pasture through cattle chute to river, northeast from two large honey locust trees standing in said chute at top of bluff, being copper bolt in tile set 3 feet below surface.
Elevation, 195.0210 meters. 639.838 feet.

P. B. M. 322 is top of cap on iron pipe set over P. B. M. 321.
Elevation 196.2401 meters. 643.838 feet.

T. B. M. 340 is about 2 miles below Harris Landing, 361 feet below the small ravine in sand bluff, at the foot of bluff on a lone blazed cottonwood tree about 28 inches in diameter, on the northwest root, being top of large spike.
Elevation, 185.4487 meters. 608.433 feet.

P. B. M. 323 is opposite the foot of Island 256, about 574 feet back from high-water line, over beyond top of same bluff, on land of Mrs. McCabe, widow; about one-half mile south of Benjamin Hatfield's house, and 62 meters south of west of a 3-foot oak tree, standing in field, at point of brush and head of small valley running east, by the wire fence on the south side of field, being a copper bolt in tile set about 3 feet under surface of ground.
Elevation, 196.2951 meters. 644.019 feet.

P. B. M. 324 is top of cap on iron pipe set over P. B. M. 323.
Elevation, 197.5134 meters. 648.016 feet.

T. B. M. 342 is midway between islands 256 and 257, 640 feet from low water's edge, about at high water line at foot of sand bluff, on a large basswood tree blazed, on the river side of tree, being a spike in the root.
Elevation, 185.6529 meters. 609.103 feet.

T. B. M. 343 is about 492 feet above the north bank of Apple River, Illinois, at the point of sand bluff where it turns up Apple River, on a large willow tree, blazed, being a spike in the root.
Elevation, 184.3855 meters. 604.945 feet.

P. B. M. 325 is at the foot of point of sand bluff on the south side of and 951 feet from left bank of Apple River, three-quarters of a mile above Arnold Landing, at the corner of cultivated land, just above high-water level, on Mr. Eddy's land, about 60 feet south of an oak tree, being a copper bolt in tile set 3 feet underground.
Elevation, 184.7633 meters. 606.184 feet.

P. B. M. 326 is top of cap on iron pipe set over P. B. M. 325.
Elevation, 185.9803 meters. 610.177 feet.

P. B. M. 327 is at Arnold Landing, Illinois, on Mr. Eddy's large brick house, at the southeast corner of main part, on the south face of the top foundation stone, 3 inches from the east end and 2 inches from top of stone, marked U.S. ⊙ P. B. M. being the center mark in a copper bolt leaded horizontally.
Elevation, 192.4387 meters. 631.366 feet.

T. B. M. 345 is about one-hlaf mile below Arnold Landing, 246 feet below the lower end of cut, and 492 feet above the long stretch of fill on the line of the Chicago, Burlington and Northern Railway, in pasture field, 60 feet west of center of track, on a 10-inch blazed white-oak tree, being largest spike in its root.
Elevation, 187.9997 meters. 616.802 feet.

P. B. M. 328 is one-half mile below Arnold landing, 98 feet above T. B. M. 345, 148 feet below lower end of long cut and 1 mile above "Marcus" Station, on the line of the Chicago, Burlington and Northern Railway, 45 feet south from center of track, on

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the north side of the south right-of-way fence, being copper bolt in tile set 3 feet underground.

Elevation, 187.1198 meters. 613.916 feet.

P. B. M. 329 is top of cap on iron pipe set over P. B. M. 328.

Elevation, 188.3289 meters. 617.883 feet.

T. B. M. 346 is at Marcus Station, directly opposite the lower head block of the southwest siding, 230 feet southwest from center of track, a blazed oak tree about 8 inches in diameter, being top of a large spike.

Elevation, 185.2034 meters. 607.628 feet.

P. B. M. 330 is 18 feet above and 27 feet from T. B. M. 346, one-fifth mile below the depot at Marcus, 200 feet above the head block at the lower end of the northeast siding, 18 feet above the head block of the southwest siding, 35 feet southwest from center of track on the southwest side, and close to wire fence, on the highest ridge of ground, 27 feet north of blazed white-oak tree, being a copper bolt in tile set 3 feet under ground.

Elevation, 184.1272 meters. 604.097 feet.

P. B. M. 331 is top of cap on iron pipe set over P. B. M. 330.

Elevation, 185.3485 meters. 608.104 feet.

T. B. M. 349 is about 2¼ miles above Savanna and 1¾ miles below Marcus, on the line of the Chicago, Burlington and Northern Railway, opposite the center of bridge No. 40, on the river side, 55 feet from center of track, on the north bank of a small stream at the point where the railroad returns to the bluff, on a root of pignut hickory about 10 inches in diameter, being top of a large spike.

Elevation, 186.6324 meters. 612.317 feet.

P. B. M. 332 is about 30 feet above T. B. M. 349, about 2¼ miles above Savanna and 1¾ miles below Marcus, on the line of the Chicago, Burlington and Northeen Railway, opposite the upper end of bridge No. 40, on river side of track, 48 feet from center, in the angle formed by the right-of-way fence and the wing fence to said bridge, being a copper bolt in tile set 3 feet below the ground.

Elevation, 185.8251 meters. 609.668 feet.

P. B. M. 333 is top of cap on iron pipe set over P. B. M. 332, about 1 foot above the ground.

Elevation, 187.0475 meters. 613.678 feet.

T. B. M. 350 is about 2¼ miles above Savanna, at the second crossing above town, on the line of the Chicago, Burlington and Northern Railway, 70 feet east from center and 5 feet below the planking of crossing at the lower point of woods and the upper side of field, one-fourth mile above Mr. McFarland's house, on the root of a large black-walnut tree, being top of large spike.

Elevation, 187.9912 meters. 616.775 feet.

P. B. M. 334 is 1¼ miles above Savanna, Ill., 443 meters below the center of bridge No. 35, about 90 feet below small white house 318 feet above milepost 284–147, and 150 feet below the point of tangent at lower end of long curve, opposite the north end of prominent portion of bare rock bluff, on the east side of the right of way, 3 feet west of high board fence, being a copper bolt in tile set 3 feet below the surface of ground.

Elevation, 186.5016 meters. 611.887 feet.

P. B. M. 335 is top of cap on iron pipe set over P. B. M. 334, standing about 1 foot above ground.

Elevation, 187.7184. 615.880 feet.

T. B. M. 353 is in Savanna, Ill., at the southeast corner of the Chicago, Milwaukee and St. Paul Railway elevator, on the third pile south of the engine room supporting the embankment of siding to elevator, being top of spike in top of pile.

Elevation, 185.1492 meters. 607.450 feet.

P. B. M. 62 is same as P. B. M. 62 in report of the Commission for 1884, page 137.

Elevation, 186.5818 meters. 612.150 feet.

Old U. S. B. M. 18 is ring bolt in Savanna, Ill., on the south side of the Chicago, Milwaukee, and St. Paul Railway elevator, about 12 feet from the west corner and 1¼ feet above the ground, being top of ring bolt leaded horizontally.

Elevation, 182.8986 meters. 600.066 feet.

P. B. M. 63 is in Savanna, Ill., same as P. B. M. 63 in report of the Commission for 1884, page 137.

Elevation, 188.8525 meters. 619.600 feet.

P. B. M. 336 is in Savanna, Ill., on the southeast corner of Main and Murray streets, on the Radke House, owned by A. McRadke, at the first doorstep from the north end of the building, on its north end, marked "U. S." ⊙ P. B. M., being top of copper bolt leaded vertically.

Elevation, 188.6128 meters. 618.814 feet.

T. B. M. 354 is in the lower end of Savanna, Ill., seven-eighths mile below the Chicago, Burlington and Northern depot 35 feet north of Jones & Jordan's boat house,

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and 50 feet west of the center of the Chicago, Burlington and Northern Railway line to Fulton, on a 10-inch elm tree, being a spike in its root.

Elevation, 185.0472 meters. 607.116 feet.

P. B. M. 337 is in Savanna, Ill., about 65 feet below T. B. M. 354, on the line of the Chicago, Burlington and Northern Railway to Fulton, 600 feet below the crossing with the Chicago, Milwaukee and St. Paul Railway to Sabula, on land of A. Hershey, 12 feet back from top of bank of slough and 15 feet below Jones & Jordan's boat house, being a copper bolt in tile set 3 feet under ground.

Elevation, 184.6559 meters. 605.832 feet.

P. B. M. 338 is top of cap on iron pipe set over P. B. M. 337, standing about a foot above the surface of the ground.

Elevation, 185.8727 meters. 609.824 feet.

P. B. M. 64 is 2¼ miles east of the Chicago, Milwaukee and St. Paul Railway Junction House. Same as P. B. M. 64, given in the report of the Mississippi River Commission for 1884, page 137.

Elevation, 187.0818 meters. 613.791 feet.

APPENDIX 4 C.

REPORT OF ASSISTANT ENGINEER JAS. A. PAIGE ON PRECISE LEVELS FROM DULUTH, MINNESOTA, TO ST. PAUL, MINNESOTA, WITH TABULATED RESULTS AND DESCRIPTIONS OF BENCHMARKS.

OFFICE MISSISSIPPI RIVER COMMISSION.
St. Louis, February 29, 1892.

SIR: I have the honor to report as follows on the precise leveling operations in my charge between Duluth and St. Paul, Minn.

In compliance with your instructions, I left St. Louis April 26, 1891, accompanied by Recorder L. D. Cabanne and Rodmen S. W. Shinkle and C. S. Farrar, arriving in Duluth the evening of the 27th. Two umbrella men and a teamster with team were employed at Duluth.

The organization of the party was: 1 observer, 1 recorder, 2 rodmen, 2 umbrella men, and a teamster with team, and a light wagon to carry the party to and from work.

Your instructions were to carry a line of precise levels from the U. S. Engineers' water gauge at Duluth by the most practicable route to St. Paul, Minn., and there connect with benchmarks established by Assistant O. W. Ferguson in starting his line down the Mississippi River.

The regular work of the season commenced April 30, and was completed to St. Paul September 25, and the levels there connected with Mr. Ferguson's permanent bench marks Nos. 68, 69, and 71. The party was disbanded on September 26, and on the 28th I reported to you at St. Louis for further duty in reducing the season's notes.

A description of various bench marks in Duluth was obtained of Capt. Fiske, Corps of Engineers, U. S. A., and they were connected with. These bench marks were used in establishing the Duluth water gauge and in maintaining it.

The instruments used were Kern level No. 2, with level vial No. 9, and Kern leveling rods Nos. 14 and 17. These instruments were used on the Mississippi River work, and are substantially the same as described in the Report of the Chief of Engineers for 1877, page 1190, and in subsequent reports.

The route of the levels was from the U. S. Engineers' water gauge at Duluth, Minn., to the St. Paul and Duluth Railway tracks; thence along the railway to Carlton, thence southward about 5 miles on the wagon road to the point where it joins the old military road between St. Paul and Superior; thence along the military road to Barnum, where the route again strikes the St. Paul and Duluth Railway; thence along the railway track to St. Paul.

Permanent bench marks were established from 4 to 6 miles apart, and elevations were taken at grade at railroad crossings and in front of various depots on the line. These bench marks consist of a slab of vitrified clay 18 inches square and 4 inches thick, into which is leaded vertically in the center of the upper face a copper bolt three-eighths of an inch thick and buried about 3.5 feet in the ground. Over this slab and surmounting the copper bolt is set a 4-inch wrought-iron pipe about 4 feet long, the lower end of which fits into a proper groove made in the slab. The top of the pipe is provided with a cap, which is fastened in place with brass bolts. The upper end of this pipe projects about 6 inches above the surface of the ground. (See illustrations of this bench mark, facing page 3485 of Report of Mississippi River Commission for 1891.) The top of the copper bolt in the slab beneath the ground is re-

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garded as the permanent bench mark, but the elevation of the top of the cap on the iron pipe is also determined. The party was subsisted at hotels, boarding houses, and such places as were available. The country passed through is but sparsely settled, there being no habitations north of Pine City outside the village along the line. This is an unsuitable method of subsisting a precise leveling party. On account of the irregular working hours, it is not possible to obtain suitable meals for the party, such as in camp, where one has entire control of his time. The hours of labor and rest are different to that of other occupations, and in order to arrange these details to suit the weather conditions a camp and cook are necessary. In the 156 miles of main line there were 62 miles over which there was no public road, and for this distance the team could not be used for transporting the party to and from work. Considerable use was made of the railway trains for about 30 miles in the vicinity of Hinckley, as the time-table suited the time of going to and from work.

The weather during the season was favorable for the work. There were but two days during which no work was done on account of rain, and eight days when work was interrupted by showers, but there were many days when the wind blew too hard for observing.

The methods used in observing during the first part of the season were about the same as those in use heretofore on this class of work. While reading the rod the vial bubble was kept at zero. No correction enters the reduction, therefore, for inclination of line of sight.

When at Pine City your instructions were received, to the effect that the order of the sights at instrument stations be alternated so that the systematic error which frequently appears in precise levels would be avoided. The method was, at Station A, for example, to read the backsight first and then the foresight; at Station B, to read the foresight first and then the backsight; at Station C, read the backsight first and then the foresight, and so on. This method was followed from T. B. M. 121 to the end of the work at St. Paul.

At T. B. M. 121 another change was intrduced in the methods. The footplates were discarded and the top of the railroad rail was used as turning points. A mark was made on top of the rail, the rod placed thereon, and the details of the rodsman's operations between a fore and back sight to the same rod station were precisely the same as when footplates were used. On curves the inner rail was used and turning points always selected at least 6 feet from a joint. The St. Paul and Duluth Railway main line is ballasted with coarse sand and gravel, well tied and spiked, and laid with 60 and 63 pound steel.

Reduction of the notes.—All the computations have been duplicated and the results compared with the field reduction. The sum of the "means of thread readings," which is the most important part of the computations, have been compared with the duplicate summation of the "thread readings."

This mean of thread readings or "mean-wire" column in the notebooks can be very well dispensed with. It is a useless and roundabout method of checking the reductions. The thread readings of the fore and back sights between the benches should be summed and one-third of their difference (in a three-wire instrument) will give the difference in elevation. This method avoids the remainders which frequently occur in deriving the mean wire, and which must be taken care of. The column of "thread readings" can be summed as often as necessary to avoid the possibility of an error, and the resulting labor is less than by the old method.

In all computations the shortest way, if it does not involve approximations or remainders, is the best way.

In platting the relative positions of the south and the north lines, where there were two or more lines in one direction, the mean of the lines in that direction has been platted.

In the tabulation of results column 2 gives the distances of the successive bench marks from the Duluth gauge.

Column 5 gives the residuals, found by subtracting each result from the mean.

Column 6 gives the probable error of the mean result in column 4.

Column 7 gives the probable error of the elevation of the permanent bench marks referred to the starting point.

The remaining columns are explained by their headings.

Instrumental constants.—The value of one division of the level vial and the inequality of the telescope collars were determined twice during the season. The lengths of rods were compared with the metric scale in the Mississippi River Commission's office at St. Louis at the close of the season. This scale is the "U. S. Lake Survey, No. 1."

The error in the length of the rods thus found, if applied to the whole difference in elevation between Duluth and St. Paul, would amount to 0.3 millimeter. As the corrections due to rod length from bench to bench is much less than that due to fluctuations of length on account of temperature changes while at work, no rod correction has been applied. This temperature range was about from 30° to 95° F.

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The following are the instrumental constants:

Instruments.	Date.	Value.
		Inches.
Kern level No. 2, telescope collar, object end larger	May 20, 1891	+1.16
	Oct. 6, 1891	−1.75
Adopted value		−0.30
Level vial, No. 9, value of one division of the bubble	Apr. 30, 1891	3.01
	Aug. 22, 1891	2.97
Adopted value		2.99
		Mm.
Leveling rods, No. 14	Sept. 30, 1891	999.948
Value of one meter, No. 17	Sept. 30, 1891	1,000.028
Mean value		999.988
Adopted value		1,000.000
Leveling rods:		
Value of A = distance from end of spur to zero of graduation: *		
No. 14	Oct. 3, 1891	44.2
No. 17	Oct. 3, 1891	44.2

* The values of A do not enter the computations. All bench marks were such that the rods were placed directly upon them.

RESULTS.

	Miles.
The distance from the Duluth gauge to permanent bench mark No. 69, at St. Paul, is 251.23 kilometers	156.2
Length of side line (3.60 kilometers)	2.2
Total (254.83 kilometers)	158.4

The field season occupied 129 days, excluding Sundays, and the progress for completed work was 1.23 miles per day for the season.

From Hinckley southward a record was kept of the times between starting at one bench and closing on the next bench ahead.

Two hundred and eighty-seven and seven-tenths kilometers were run in 232.9 hours. This is an actual speed while at work of 1,231 meters per hour.

The probable error in the elevation of permanent bench mark No. "A," at St. Paul, is 15.7 millimeters. This gives a probable error in the work of 0.99 millimeters per kilometer. An inspection of the plat of the relative positions of the two lines shows that from the Duluth gauge to T. B. M. 51, at Blackhoof River, there is a total divergence of 93.1 millimeters. For this portion of the line (53.2 kilometers long) the average departure of the lines is 1.8 millimeters per kilometer, the elevations by the south line being lower than by the north line. The ground leveled over was a newly constructed railroad bed and a light sandy wagon road. From T. B. M. 51 to Barnum the wagon road was mostly hard clay and gravel, and from Barnum to St. Paul the surface was a hard, well-settled railroad bed of coarse sand and gravel. From Duluth to T. B. M. 51 it was necessary to level 44 per cent of the distance more than twice. Now, if we reject all lines except the first two (south and north) we will get a result for T. B. M. 51 which differs but 9 millimeters from the adopted result by taking all the lines run. This is pretty good evidence of itself that a systematic error appears in the work up to this point. If this error had been eliminated by some change in the methods or by choosing another route, the probable error of 0.99 millimeter per kilometer would have been somewhat reduced. However, the result thus obtained for T. B. M. 51 would probably not have been any nearer the truth than the one we now have.

From T. B. M. 51 southward for 100 miles the general tendency of the lines is toward each other, the total discrepancy at T. B. M. 171 being 13.4 millimeters. From this point the lines again diverge, ending at St. Paul on P. B. M. 69 with a difference of 42.4 millimeters.

As to the method of alternating the order of the fore and back sights at successive instrument stations, it is not possible to discuss the effect of it on this piece of work, as it is combined with that due to a change in turning points from footplate to rail. They may be counterbalancing in effect, or they may be accumulative. From this season's results we can not determine their relative size or their signs. Alternating the order of the sights will tend to lessen the aggregate amount of settling

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of the leveling instrument at the various stations. In any class of levels where but a single line is run it would be well to follow this method, as the single result will then be (partly) cleared of the error due to the leveling instrument settling. There are cases also when two lines are run, and in opposite directions, where it would be well to adopt this method, such, for example, as where the routes of the direct and reverse lines between two bench marks are not the same; also, when from rains or other causes the surface conditions are dissimilar for the two lines.

In the practice of precise levels the two cases above mentioned are of rare occurrence; in fact, they should be avoided altogether.

Let x be the aggregate sinking (or rising) of the leveling instruments between any two consecutive bench marks. Then when, for any reason, we think that x will change in size or sign between the direct and reverse leveling, it would be well to alternate the order of the sights at the successive stations. However, in precise leveling the routes and other conditions should be such that x will not change between bench marks. The method will tend to reduce the range in the results, and hence the probable error, and in precise levelling this is about all that can be said for it.

As to using the top of the rail for rod support that, of course, must depend on the physical condition of the track and frequency of trains. When the change was first made in turning points at Pine City, stakes were driven at the side of the roadbed to avoid trains when they approached.

From some experiments made by taking the elevation of the rail before and after trains passed, there were some differences found. These differences were irregular in sign and nearly all within the limits of error in observing. After this no attention was paid to trains in this respect.

There may be individual movements of the rail, but on a stone or gravel ballasted track, well tied and spiked and laid with steel, such as was found between Pine City and St. Paul, I think the aggregate rod movement on the rail is less than for foot plates, stakes, or any kind of rod support that is practicable. With the completion of this line there will be two connections of the Mississippi River system of precise levels with the elevations of lakes Michigan and Superior, the first connection being that made between Savanna, Ill., and Chicago in 1882. (See Report of the Mississippi River Commission for 1883, p. 53, and Report for 1884, p. 116.) When the mean elevation of Lake Superior at the Duluth gauge is derived from the readings there, extending over a period of years, the two results can then be compared.

Respectfully submitted.

JAMES A. PAIGE,
U. S. Assistant Engineer.

Capt. CARL F. PALFREY,
Secretary Mississippi River Commission.

Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891.

By Assistant Engineer JAMES A. PAIGE.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		Meters.	Mm.	Mm.	Mm.	Meters.	Feet.
Zero of Duluth water gauge							189.4599	621.593
Three-foot mark on Duluth gauge			+ 0.9144				190.3743	624.593
T. B. M. 1	.31	S	+ 0.7642	+ 0.2	0.2		191.1387	627.101
		N	+ 0.7647	− 0.3				
		Mean	+ 0.7644					
B. M. 1 of U. S. Engineers at Duluth	1.22	S	+ 6.0909	+ 1.7	1.2	1.2	197.2313	647.090
		N	+ 6.0944	− 1.8				
		Mean	+ 6.0926					
"B. M. 19" of U. S. Engineers at Duluth	1.43	S	− 5.9261	− 0.2	0.1	1.2	191.3050	627.647
		N	− 5.9265	+ 0.2				
		Mean	− 5.9263					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 3	2.21	S	+ 0.5695	+ 3.6	0.9	......	191.8781	629.527
		N	+ 0.5743	− 1.2				
		N	+ 0.5760	− 2.9				
		S	+ 0.5726	+ 0.5				
		Mean	+ 0.5731					
"B. M. 23" of U. S. Engineers at Duluth*	2.31	S	+ 0.0034	......	......	......	191.8815	629.538
T. B. M. 4	2.79	S	− 0.9416	+ 2.4	0.9	......	190.9389	626.446
		N	− 0.9369	− 2.3				
		S	− 0.9390	− 0.2				
		Mean	− 0.9392					
T. B. M. 6	3.80	S	+ 0.1694	+ 0.4	0.3	......	191.1087	627.003
		N	+ 0.1703	− 0.5				
		Mean	+ 0.1698					
T. B. M. 7	5.87	S	+ 6.3228	− 2.1	1.4	......	197.4294	647.740
		N	+ 6.3186	+ 2.1				
		Mean	+ 6.3207					
T. B. M. 10	7.64	S	+ 0.6781	− 0.1	0.1	......	198.1074	649.964
		N	+ 0.6779	+ 0.1				
		Mean	+ 0.6780					
T. B. M. 11	8.49	S	− 1.8497	+ 1.8	1.2	......	196.2595	643.902
		N	− 1.8461	− 1.8				
		Mean	− 1.8479					
B. M. in "Iron Bay Iron Works" building*	8.67	S	+ 1.5148	+ 0.7	0.5	2.6	197.7750	648.874
		N	+ 1.5162	− 0.7				
		Mean	+ 1.5155					
T. B. M. 12	10.21	S	+ 5.2470	+ 2.7	1.1	......	201.5092	661.125
		N	+ 5.2529	− 3.2				
		N	+ 5.2493	+ 0.4				
		Mean	+ 5.2497					
U. S. P. B. M. 1*	10.35	S	− 1.8384	− 0.2	0.2	2.8	199.6706	655.093
		N	− 1.8389	+ 0.3				
		Mean	− 1.8386					
U. S. P. B. M. 1 A. from T. B. M. 12	10.36	S	− 0.6265	+ 0.2	0.1	2.8	200.8829	659.071
		N	− 0.6262	− 0.1				
		Mean	− 0.6263					
T. B. M. 14 from T. B. M. 12	11.25	S	− 1.0355	− 1.1	0.8	......	200.4726	657.724
		N	− 1.0378	+ 1.2				
		Mean	− 1.0366					
T. B. M. 17	13.21	S	+ 6.4113	+ 0.4	0.3	......	206.8843	678.760
		N	+ 6.4121	− 0.4				
		Mean	+ 6.4117					
T. B. M. 17 A	14.91	S	+15.2642	+ 3.9	1.3	......	222.1524	728.853
		N	+15.2704	− 2.3				
		S	+15.2698	− 1.7				
		Mean	+15.2681					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
U.S.P.B.M.2 from 17 A *	14.92	S	— 1.7813	+ 0.5	0.3	3.2	220.3716	723.010
		N	— 1.7803	— 0.5				
		Mean	— 1.7808					
U.S.P.B.M.2 A. from 17 A	14.93	S	— 0.5666	— 0.9	0.2	3.2	221.5849	726.991
		N	— 0.5674	— 0.1				
		N	— 0.5679	+ 0.4				
		S	— 0.5680	+ 0.5				
		Mean	— 0.5675					
Base of rail at Smithville depot from P.B.M.2 A *	15.28	S	+ 5.9799	......	......	......	227.5648	746.610
T.B.M.18 from P.B.M.2 A	16.85	S	+21.4150	0.0	0.0	......	242.9999	797.251
		N	+21.4150	0.0				
		Mean	+21.4150					
T.B.M.19	18.15	S	+12.1657	+ 7.9	2.9	......	255.1735	837.191
		N	+12.1792	— 5.6				
		S	+12.1670	+ 6.6				
		N	+12.1827	— 9.1				
		Mean	+12.1736					
T.B.M.20	19.41	S	+ 9.7444	— 8.0	1.9	......	264.9099	869.135
		N	+ 9.7313	+ 5.1				
		N	+ 9.7347	+ 1.7				
		S	+ 9.7352	+ 1.2				
		Mean	+ 9.7364					
T.B.M.21	20.73	S	+12.3613	— 1.6	1.9	......	277.2696	909.685
		N	+12.3553	+ 4.4				
		N	+12.3672	— 7.5				
		S	+12.3549	+ 4.8				
		Mean	+12.3597					
T.B.M.22	22.73	S	+20.0527	+ 6.4	2.9	......	297.3287	975.497
		N	+20.0653	— 6.2				
		N	+20.0676	— 8.5				
		S	+20.0507	+ 8.4				
		Mean	+20.0591					
U.S.P.B.M.3, from T.B.M. 22 *	22.74	S	+ 0.1453	— 0.3	0.2	5.9	297.4737	975.972
		N	+ 0.1447	+ 0.3				
		Mean	+ 0.1450					
U.S.P.B.M.3 A., from T.B.M.22 *	22.74	S	+ 1.3627	0.0	0.2	5.9	298.6914	979.967
		N	+ 1.3623	+ 0.4				
		N	+ 1.3634	— 0.7				
		N	+ 1.3623	+ 0.4				
		Mean	+ 1.3627					
T.B.M.23 from T.B.M.22	24.69	S	+ 18.2399	+ 1.5	1.0	......	315.5701	1,035.344
		N	+ 18.2430	— 1.6				
		Mean	+ 18.2414					
T.B.M.24	26.34	S	+ 18.0724	+ 8.4	3.3	......	333.6509	1,094.665
		N	+ 18.0873	— 6.5				
		S	+ 18.0913	—10.5				
		N	+ 18.0721	+ 8.7				
		Mean	+ 18.0808					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28080928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 25	27.01	S	+ 4.3701	+ 3.9	1.3	......	338.0249	1,109.015
		N	+ 4.3758	— 1.8				
		S	+ 4.3760	— 2.0				
		Mean	+ 4.3740					
T. B. M. 26	28.70	S	+ 6.5788	13.5	Rejected.			
		N	+ 6.6007	— 3.9	1.3	......	344.6217	1,130.659
		S	+ 6.5947	+ 2.1				
		N	+ 6.5949	+ 1.9				
		Mean	+ 6.5968					
T. B. M. 28	30.27	S	— 8.2767	0.0	0.0	......	336.3450	1,103.504
		N	— 8.2767	0.0				
		Mean	— 8.2767					
T. B. M. 29	31.46	S	— 3.4860	+ 5.2	1.7	......	332.8642	1,092.084
		N	— 3.4785	— 2.3				
		S	— 2.4780	— 2.8				
		Mean	— 3.4808					
U. S. P. B. M. 4, from T. B. M. 29 *	31.50	S	— 0.4333	+ 0.4	0.2	7.2	332.4313	1,090.664
		N	— 0.4326	— 0.3				
		Mean	— 0.4329					
U. S. P. B. M. 4 A, from T. B. M. 29 *	31.50	S	+ 0.7797	— 0.6	0.4	7.2	333.6433	1,094.640
		N	+ 0.7784	+ 0.7				
		Mean	+ 0.7791					
T. B. M. 31, from T. B. M 29	33.58	S	— 6.2461	— 0.4	0.3	......	326.6177	1,071.590
		N	— 6.2470	+ 0.5				
		Mean	— 6.2465					
T. B. M. 32	35.26	S	+ 7.9318	+ 0.4	0.3	......	334.5499	1,097.614
		N	+ 7.9326	— 0.4				
		Mean	+ 7.9322					
U. S. P. B. M. 5, from T. B. M. 32 *	35.83	S	+ 3.7272	+ 1.2	0.8	7.3	338.2783	1,109.847
		N	+ 3.7297	— 1.3				
		Mean	+ 3.7284					
T. B. M. 34 from T. B. M. 32	36.45	S	+ 5.6878	+ 1.4	1.0	......	340.2391	1,116.280
		N	+ 5.6907	— 1.5				
		Mean	+ 5.6892					
T. B. M. 35	37.68	S	+ 35.5379	+ 0.6	0.4	......	375.7776	1,232.877
		N	+ 35.5392	— 0.7				
		Mean	+ 35.5385					
T. B. M. 36	39.17	S	— 3.9392	— 0.3	0.2	......	371.8381	1,219.952
		N	— 3.9399	+ 0.4				
		Mean	— 3.9395					
T. B. M. 37	40.18	S	— 24.2304	— 1.1	0.7	......	347.6066	1,140.452
		N	— 24.2325	+ 1.0				
		Mean	— 24.2315					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 39	41.97	S	− 2.7807	− 4.4	1.5	......	344.8215	1,131.314
		N	− 2.7865	+ 1.4				
		N	− 2.7881	+ 3.0				
		Mean	− 2.7851					
T. B. M. 40	43.70	S	− 2.0420	+ 1.5	1.0	......	342.7810	1,124.620
		N	− 2.0390	− 1.5				
		Mean	− 2.0405					
T. B. M. 42	44.47	S	+ 2.9785	− 1.0	0.6	......	345.7585	1,134.388
		N	+ 2.9766	− 0.9				
		Mean	+ 2.9775					
U. S. P. B. M. 6 from T. B. M. 42*	44.49	S	− 0.2520	+ 0.2	0.1	7.6	345.5067	1,133.562
		N	− 0.2516	− 0.2				
		Mean	− 0.2518					
U. S. P. B. M. 6 A from T. B. M. 42*	44.49	S	+ 0.9623	− 0.2	0.1	7.6	346.7206	1,137.545
		N	+ 0.9620	+ 0.1				
		Mean	+ 0.9621					
T. B. M. 43 from T. B. M. 42	45.60	S	+ 3.8852	+ 0.6	0.4	......	349.6443	1,147.137
		N	+ 3.8864	− 0.6				
		Mean	+ 3.8858					
T. B. M. 45	46.09	S	− 6.2814	− 0.3	0.2	......	343.3026	1,126.528
		N	− 6.2820	+ 0.3				
		Mean	− 6.2817					
T. B. M. 47	47.69	S	− 1.5976	− 1.0	0.7	......	341.7640	1,121.283
		N	− 1.5996	+ 1.0				
		Mean	− 1.5986					
T. B. M. 48	49.13	S	− 1.7852	+ 6.6	1.7	......	339.9854	1,115.448
		N	− 1.7769	− 1.7				
		S	− 1.7730	− 5.6				
		N	− 1.7794	+ 0.8				
		Mean	− 1.7786					
T. B. M. 49	50.37	S	+ 5.2675	+ 2.5	1.1	......	345.2554	1,132.738
		N	+ 5.2741	− 4.1				
		S	+ 5.2713	− 1.3				
		N	+ 5.2670	+ 3.0				
		Mean	+ 5.2700					
T. B. M. 50	51.98	S	+ 4.7327	+ 8.9	2.4	......	349.9970	1,148.294
		N	+ 4.7501	− 8.5				
		N	+ 4.7439	− 2.3				
		S	+ 4.7399	+ 1.7				
		Mean	+ 4.7416					
T. B. M. 51	53.21	S	−10.5687	+12.5	3.1	......	339.4408	1,113.661
		N	−10.5469	− 9.3				
		N	−10.5518	− 4.4				
		S	−10.5573	+ 1.1				
		Mean	−10.5562					
U. S. P. B. M. 7 from T. B. M. 51*	53.24	S	− 0.7600	− 0.1	0.1	8.8	338.6807	1,111.167
		N	− 0.7603	+ 0.2				
		Mean	− 0.7601					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
U. S. P. B. M. 7 A from T. B. M. 51 *	53.24	S	+ 0.4580	+ 0.3	0.1	8.8	339.8991	1,115.165
		N	+ 0.4587	− 0.4				
		S	+ 0.4583	0.0				
		Mean	+ 0.4583					
T. B. M. 52 from T. B. M. 51	54.51	S	+17.3212	− 3.5	0.8	......	356.7585	1,170.478
		N	+17.3169	+ 0.8				
		N	+17.3153	+ 2.4				
		S	+17.3176	+ 0.1				
		Mean	+17.3177					
T. B. M. 53	55.93	S	− 6.3385	− 2.5	1.7	......	350.4175	1,149.674
		N	− 6.3435	+ 2.5				
		Mean	− 6.3410					
T. B. M. 54	57.41	S	+ 5.8426	− 2.4	1.6	......	356.2577	1,168.835
		N	+ 5.8378	+ 2.4				
		Mean	+ 5.8402					
T. B. M. 55	58.28	S	+15.3346	− 1.5	1.0	......	371.5908	1,219.141
		N	+15.3317	+ 1.4				
		Mean	+15.3331					
T. B. M. 56	59.43	S	− 7.7034	− 0.6	0.4	......	363.8868	1,193.865
		N	− 7.7046	+ 0.6				
		Mean	− 7.7040					
U. S. P. B. M. 8 from T. B. M. 56	60.77	S	− 2.4653	+ 0.3	0.2	9.2	361.4218	1,185.778
		N	− 2.4648	− 0.2				
		Mean	− 2.4650					
U. S. P. B. M. 8 A from P. B. M. 8 *	60.77	S	+ 1.2100	0.0	0.0	9.2	362.6318	1,189.748
		N	+ 1.2100	0.0				
		Mean	+ 1.2100					
T. B. M. 57 from P. B. M. 8	62.52	S	+ 4.1251	+ 0.7	0.5	......	365.5476	1,199.314
		N	+ 4.1265	− 0.7				
		Mean	+ 4.1258					
T. B. M. 58	64.13	S	−11.7086	+ 0.3	0.2	......	353.8393	1,160.900
		N	−11.7081	− 0.2				
		Mean	−11.7083					
U. S. P. B. M. 9	65.70	S	+12.4909	− 4.4	1.3	9.4	366.3258	1,201.867
		N	+12.4827	+ 3.8				
		N	+12.4890	− 2.5				
		S	+12.4835	+ 3.0				
		Mean	+12.4865					
U. S. P. B. M. 9 A from P. B. M. 9.*	65.76	S	+ 1.2227	+ 0.3	0.2	9.4	367.5488	1,205.880
		N	+ 1.2234	− 0.4				
		Mean	+ 1.2230					
T. B. M. 59 from P. B. M. 9	66.96	S	−25.5817	− 1.6	1.1	......	340.7425	1,117.932
		N	−25.5850	+ 1.7				
		Mean	−25.5833					
Base of rail at Barnum from T. B. M. 59 *	67.05	S	− 0.3156	......	......	......	340.4269	1,116.896

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench mark.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 60 from T. B. M. 59	68.58	S	− 0.8476	− 0.9	0.6	......	339.8940	1,115.148
		N	− 0.8494	+ 0.9				
		Mean	− 0.8485					
T. B. M. 61	70.13	S	+ 1.2281	− 1.9	1.2	......	341.1202	1,119.171
		N	+ 1.2243	+ 1.9				
		Mean	+ 1.2262					
T. B. M. 62	71.62	S	− 4.5139	− 2.5	1.7	......	336.6038	1,104.353
		N	− 4.5189	+ 2.5				
		Mean	− 4.5164					
T. B. M. 63	73.23	S	− 4.5807	− 6.1	1.7	......	332.0170	1,089.304
		N	− 4.5923	+ 5.5				
		S	− 4.5890	+ 2.2				
		N	− 4.5854	− 1.4				
		Mean	− 4.5868					
T. B. M. 63 A	73.70	S	− 0.6616	+ 0.5	0.3	......	331.3559	1,087.135
		N	− 0.6607	− 0.4				
		Mean	− 0.6611					
T. B. M. 64	74.40	S	− 1.4947	+ 0.1	0.0	......	329.8613	1,082.232
		N	− 1.4946	0.0				
		Mean	− 1.4946					
U. S. P. B. M. 10 from T. B. M. 64*	74.43	S	− 0.6717	+ 0.1	0.1	9.8	329.1897	1,080.028
		N	− 0.6714	− 0.2				
		Mean	− 0.6716					
U. S. P. B. M. 10 A from T. B. M. 64 *	74.43	S	+ 0.5447	0.0	0.0	9.8	330.4060	1,084.019
		N	+ 0.5447	0.0				
		Mean	+ 0.5447					
Base of rail at Moose Lake depot from T. B. M. 64.	74.47	S	+0.3623	......	......	......	330.2236	1,083.420
T. B. M. 65 from T. B. M. 64	75.96	S	−1.0499	+6.5	1.5	......	328.8179	1,078.809
		N	−1.0408	−2.6				
		S	−1.0403	−3.1				
		N	−1.0424	−1.0				
		Mean	−1.0434					
T. B. M. 66	77.66	S	−2.3684	+0.3	0.2	......	326.4498	1,071.039
		N	−2.3679	−0.2				
		Mean	−2.3681					
T. B. M. 67	79.34	S	+8.8156	+1.0	0.7	......	335.2664	1,099.965
		N	+8.8177	−1.1				
		Mean	+8.8166					
T. B. M. 68	81.02	S	+3.0647	−1.6	1.1	......	338.3295	1,110.015
		N	+3.0615	+1.6				
		Mean	+3.0631					
T. B. M. 69	82.25	S	+1.3785	+1.8	1.2	......	339.7098	1,114.543
		N	+1.3822	−1.9				
		Mean	+1.3803					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 70	83.86	S N	−5.8936 −5.8957	−1.1 +1.0	0.7	......	333.8151	1,095.204
		Mean	−5.8947					
T. B. M. 71	84.20	S N	+0.5370 +0.5374	+0.2 −0.2	0.1	......	334.3523	1,096.966
		Mean	+0.5372					
U. S. P. B. M. 11 from T. B. M. 71 *	84.33	S N	−2.7494 −2.7486	+0.4 −0.4	0.3	10.1	331.6033	1,087.947
		Mean	−2.7490					
U. S. P. B. M. 11 A. from T. B. M. 71 *	84.32	S N	−1.5253 −1.5260	−0.4 +0.3	...... 0.2	10.1	332.8266	1,091.961
		Mean	−1.5257					
T. B. M. 72 from T. B. M. 71	85.76	S N S	−2.9747 −2.9854 −2.9820	−6.0 +4.7 +1.3	2.1	......	331.3716	1,087.187
		Mean	−2.9807					
T. B. M. 73	87.16	S N	−5.8120 −5.8143	−1.1 +1.2	0.8	......	325.5585	1,068.115
		Mean	−5.8131					
T. B. M. 74	88.67	S N	−0.2830 −0.2879	−2.4 +2.5	1.5	......	325.2731	1,067.179
		Mean	−0.2854					
T. B. M. 75	90.17	S N	−1.8697 −1.8730	−1.6 +1.7	1.1	......	323.4018	1,061.039
		Mean	−1.8713					
T. B. M. 76	91.82	S N	−1.7030 −1.7006	+1.2 −1.2	0.8	......	321.7000	1,055.456
		Mean	−1.7018					
U. S. P. B. M. 12 from T. B. M. 76*	92.04	S N	−2.4188 −2.4195	−0.3 +0.4	0.2	10.5	319.2809	1,047.519
		Mean	−2.4191					
U. S. P. B. M. 12 A from T. B. M. 76*	92.04	S N	−1.2041 −1.2051	−0.5 +0.5	0.3	10.5	320.4954	1,051.504
		Mean	−1.2046					
T. B. M. 77 from T. B. M. 76	93.73	S N S N	+6.9074 +6.9017 +6.9077 +6.8964	−4.1 +1.6 −4.4 +6.9	1.8	......	328.6033	1,078.104
		Mean	+6.9033					
T. B. M. 78	95.38	S N	−2.0410 −2.0368	+2.1 −2.1	1.4	......	326.5644	1,071.415
		Mean	−2.0389					

Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1, to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 79	97.04	S	—6.1814	—1.4	1.9	......	320.3816	1,051.130
		N	—6.1882	+5.4				
		N	—6.1789	—3.9				
		Mean	—6.1828					
T. B. M. 80	98.05	S	—0.4784	+1.7	1.1	......	319.9049	1,049.566
		N	—0.4750	—1.7				
		Mean	—0.4767					
Base of rail at Kettle River depot from T. B. M. 80*	98.20	N	+0.7023	......	......	......	320.6072	1,051.870
U. S. P. B. M. 13 from T. B. M. 80*	98.15	S	+0.3400	—1.2	0.4	11.0	320.2437	1,050.678
		N	+0.3383	+0.5				
		S	+0.3380	+0.8				
		Mean	+0.3388					
U. S. P. B. M 13 A from T. B. M. 80*	98.15	S	+1.5544	—0.5	0.3	11.0	321.4588	1,054.664
		N	+1.5534	+0.5				
		Mean	+1.5539					
T. B. M. 81 from T. B. M. 80	99.75	S	+2.3810	—1.8	1.2	......	322.2841	1,057.372
		N	+2.3774	+1.8				
		Mean	+2.3792					
T. B. M. 82	101.23	S	+6.2510	—2.2	1.3	......	328.5329	1,077.87
		N	+6.2432	+5.6				
		S	+6.2488	0.0				
		N	+6.2520	—3.2				
		Mean	+6.2488					
T. B. M. 83	102.63	S	+5.9574	+1.2	0.8	......	334.4915	1,097.423
		N	+5.9598	—1.2				
		Mean	+5.9586					
T. B. M. 84	103.54	S	+5.2055	+0.6	0.4	......	339.6976	1,114.503
		N	+5.2067	—0.6				
		Mean	+5.2061					
T. B. M. 85	105.14	S	+5.4996	+1.4	0.9	......	345.1986	1,132.551
		N	+5.5024	—1.4				
		Mean	+5.5010					
T. B. M. 86	106.15	S	—1.3897	—0.8	0.6	......	343.8081	1,127.989
		N	—1.3914	+0.9				
		Mean	—1.3905					
Base of rail at Finlayson depot from T. B. M. 86*	106.25	S	+1.4496	......	......	......	345.2577	1,132.745
T. B. M. 87 from T. B. M. 86	107.69	S	+4.1490	+0.8	0.5	......	347.9579	1,141.604
		N	+4.1506	—0.8				
		Mean	+4.1498					
T. B. M. 88	108.32	S	—1.2087	+2.6	0.9	......	346.7518	1,137.647
		N	—1.2028	—3.3				
		N	—1.2054	—0.7				
		S	—1.2077	+1.6				
		Mean	—1.2061					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V	r	R	Elevation above Cairo datum.	
	Km.		Meters.	Mm.	Mm.	Mm.	Meters.	Feet.
T. B. M. 89	109.49	S	+4.2859	+1.0	0.7	......	351.0387	1,151.712
		N	+4.2879	−1.0				
		Mean	+4.2869					
T. B. M. 90	111.12	S	−0.1343	+0.1	0.1	......	350.9045	1,151.272
		N	−0.1340	−0.2				
		Mean	−0.1342					
T. B. M. 91	112.00	S	−0.2746	+1.7	1.1	......	350.6282	1,150.365
		N	−0.2780	−1.7				
		Mean	−0.2763					
Base of rail at Miller from T. B. M. 91*	112.32	N	+1.2687	......	......	......	351.8969	1,154.528
U. S. P. B. M. 14 from T. B. M. 91*	112.03	S	−0.1444	0.0	0.0	11.4	350.4838	1,149.892
		N	−0.1444	0.0				
		Mean	−0.1444					
U. S. P. B. M. 14 A. from T. B. M. 91*	112.03	S	+1.0673	+0.4	0.2	11.4	351.6959	1,153.868
		N	+1.0680	−0.3				
		Mean	+1.0677					
T. B. M. 92 from T. B. M. 91	113.39	S	−1.2373	−0.2	0.2	......	349.3907	1,146.305
		N	−1.2378	+0.3				
		Mean	−1.2375					
T. B. M. 93	114.43	S	−0.7700	0.0	0.0	......	348.6207	1,143.779
		N	−0.7700	0.0				
		Mean	−0.7700					
T. B. M. 94	115.57	S	−0.9670	−3.3	1.3	......	347.6504	1,140.596
		N	−0.9720	+1.7				
		N	−0.9750	+4.7				
		S	−0.9673	−3.0				
		Mean	−0.9703					
U. S. P. B. M. 15 from T. B. M. 94*	115.65	S	−0.3792	+0.2	0.3	11.5	347.2714	1,139.352
		S	−0.3782	−0.8				
		S	−0.3795	+0.5				
		Mean	−0.3790					
U. S. P. B. M. 15 A. from T. B. M. 94*	115.65	N	+0.8399	+0.1	0.1	11.5	348.4904	1,143.351
		N	+0.8402	−0.2				
		Mean	+0.8400					
T. B. M. 95 from T. B. M. 94	116.05	S	−2.5787	+0.8	0.5	......	345.0725	1,132.138
		N	−2.5772	−0.7				
		Mean	−2.5779					
T. B. M. 96	117.31	S	−2.0808	−3.4	1.6	......	342.9883	1,125.300
		N	−2.0887	+4.5				
		N	−2.0831	−1.1				
		Mean	−2.0842					
T. B. M. 99	119.11	S	+3.1931	+0.2	0.2	......	346.1816	1,135.777
		N	+3.1936	−0.3				
		Mean	+3.1933					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 100	120.41	S	−0.6516	0.0	0.0	......	345.5300	1,133.639
		N	−0.6517	+0.1				
		Mean	−0.6516					
T. B. M. 101	121.45	S	−4.6444	+0.5	0.4	......	340.8861	1,118.403
		N	−4.6433	−0.6				
		Mean	−4.6439					
T. B. M. 102	122.57	S	−2.6537	+1.5	1.0	......	338.2339	1,109.701
		N	−2.6507	−1.5				
		Mean	−2.6522					
T. B. M. 103	123.98	S	−1.2516	+1.4	0.9	......	336.9837	1,105.599
		N	−1.2489	−1.3				
		Mean	−1.2502					
T. B. M. 104	125.40	S	−9.3940	+1.1	0.8	......	327.5908	1.074.783
		N	−9.3917	−1.2				
		Mean	−9.3929					
U. S. P. B. M. 16	126.75	S	−7.6757	+1.2	0.8	11.7	319.9163	1,049.604
		N	−7.6733	−1.2				
		Mean	−7.6745					
Base of rail at Hinckley depot from P. B. M. 16*	127.37	S	+1.3960	......	......	......	321.3123	1,054.184
T. B. M. 105 from P. B. M. 16	127.79	S	+0.9531	−1.0	0.6	......	320.8684	1,052.727
		N	+0.9512	+0.9				
		Mean	+0.9521					
U. S. P. B. M. 17 from T. B. M. 105 *	127.81	S	−0.6634	−0.4	0.3	11.8	320.2046	1,050.549
		N	−0.6643	+0.5				
		Mean	−0.6638					
U. S. P. B. M. 17 A. from T. B. M. 105*	127.81	S	+0.5560	+0.1	0.1	11.8	321.4245	1,054.552
		S	+0.5563	−0.2				
		Mean	+0.5561					
T. B. M. 106 from T. B. M. 105	129.43	S	−5.4849	+1.9	1.2	......	315.3854	1,034.738
		N	−5.4812	−1.8				
		Mean	−5.4830					
T. B. M. 107	130.79	S	−0.5673	+3.0	1.3	......	314.8211	1,032.887
		N	−0.5587	−5.6				
		S	−0.5656	+1.3				
		N	−0.5655	+1.2				
		Mean	−0.5643					
T. B. M. 108	132.22	S	−4.0994	−2.0	1.3	......	310.7197	1,019.431
		N	−4.1034	+2.0				
		Mean	−4.1014					
Base of rail at Mission Creek depot from T. B. M. 108*	132.53	N	−0.7879	......	......	......	309.9318	1,016.846
T. B. M. 109 from T. B. M. 108	133.28	S	−2.8154	+0.4	0.3	......	307.9047	1,010.195
		N	−2.8146	−0.4				
		Mean	−2.8150					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
U. S. P. B. M. 18 from T. B. M. 109 *	133.33	S	−1.0846	+0.2	0.1	11.9	306.8203	1,006.637
		N	−1.0842	−0.2				
		Mean .	−1.0844					
U. S. P. B. M. 18 A. from T. B. M. 109 *	133.33	S	+0.1361	−0.2	0.1	11.9	308.0406	1,010.641
		N	+0.1357	+0.2				
		Mean .	+0.1359					
T. B. M. 110 from T. B. M. 109	134.74	S	−2.8693	−2.5	1.7	......	305.0329	1,000.773
		N	−2.8744	+2.6				
		Mean .	−2.8718					
T. B. M. 111	136.18	S	−3.7879	−4.6	1.8	......	301.2404	988.330
		N	−3.7970	+4.5				
		S	−3.7926	+0.1				
		Mean .	−3.7925					
T. B. M. 112	137.22	S	−0.9520	−0.8	0.6	......	300.2876	985.204
		N	−0.9537	+0.9				
		Mean .	−0.9528					
T. B. M. 113	138.42	S	+3.7238	+0.1	0.1	......	304.0115	997.422
		N	+3.7241	−0.2				
		Mean .	+3.7239					
* U. S. P. B. M. 19 from T. B. M. 113	138.53	S	−1.1380	0.0	0.0	12.2	302.8735	993.688
		N	−1.1380	0.0				
		Mean .	−1.1380					
* U. S. P. B. M. 19 A from T. B. M. 113	138.53	S	+0.0800	+0.8	0.4	12.2	304.0923	997.687
		N	+0.0820	−1.2				
		N	+0.0804	+0.4				
		Mean .	+0.0808					
* Base of rail at Brown's Hill from T. B. M. 113	138.79	S	+0.0877	......	......	......	304.0992	997.710
T. B. M. 114 from T. B. M. 113	139.51	S	−2.3116	+1.7	1.1	......	301.7016	989.844
		N	−2.3083	−1.6				
		Mean .	−2.3099					
T. B. M. 115	140.84	S	+1.5359	+2.2	1.5	......	303.2397	994.890
		N	+1.5403	−2.2				
		Mean .	+1.5381					
T. B. M. 116	141.98	S	+3.3750	+2.1	1.4	......	306.6168	1005.970
		N	+3.3793	−2.2				
		Mean .	+3.3771					
T. B. M. 117	143.58	S	−3.9721	+1.2	0.8	......	297.5459	976.209
		N	−0.0698	−1.1				
		Mean .	−9.0709					
T. B. M. 118	145.35	S	+0.9627	+0.1	0.1	......	298.5087	979.368
		N	+0.9629	−0.1				
		Mean .	+0.9628					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.2808d928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	v.	r.	R.	Elevation above Cario datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 119	146.84	S	—1.0979	—0.4	1.4	......	297.4104	975.765
		N	—1.1043	+6.0				
		S	—1.0966	—1.7				
		N	—1.0944	—3.9				
		Mean	—1.0983					
T. B. M. 120	147.91	S	—1.9790	—1.5	1.0	......	295.4299	969.267
		N	—1.9820	+1.5				
		Mean	—1.9805					
U. S. P. B. M. 20	148.23	S	—0.0950	—0.1	0.1	12.6	295.3348	968.955
		N	—0.0953	+0.2				
		Mean	—0.0951					
T. B. M. 121	148.64	S	+1.2504	—0.4	0.3	......	296.5848	973.056
		N	+1.2496	+0.4				
		Mean	+1.2500					
* U. S. P. B. M. 21 from T. B. M. 121	148.71	S	—2.0326	—0.2	0.1	12.6	294.5520	966.387
		N	—2.0330	+0.2				
		Mean	—2.0328					
* U. S. P. B. M. 21 A, from T. B. M. 121	148.71	S	—0.8123	+0.3	0.2	12.6	295.7728	970.392
		N	—0.8117	—0.3				
		Mean	—0.8120					
T. B. M. 122 from T. B. M. 121	149.81	S	+4.0999	—2.1	1.4	......	300.6826	986.500
		N	+4.0957	+2.1				
		Mean	+4.0978					
T. B. M. 123	150.89	S	+3.7453	—3.1	1.2	......	304.4248	998.778
		N	+3.7390	+3.2				
		N	+3.7423	—0.1				
		Mean	+3.7422					
T. B. M. 124	152.22	S	—0.5680	—1.2	0.8	......	303.8556	996.911
		N	—0.5704	+1.2				
		Mean	—0.5692					
T. B. M. 125	153.18	S	—1.3677	+1.2	0.8	......	302.4891	992.427
		N	—1.3653	—1.2				
		Mean	—1.3665					
T. B. M. 126	154.65	S	—4.6243	+1.9	1.3	......	297.8667	977.262
		N	—4.6205	—1.9				
		Mean	—4.6224					
T. B. M. 127	156.34	S	—5.0317	—4.5	1.1	......	292.8305	960.739
		N	—5.0379	+1.7				
		N	—5.0396	+3.4				
		N	—5.0355	—0.7				
		Mean	—5.0362					
* U. S. P. B. M. 22 from T. B. M. 127	156.43	S	—1.8972	0.0	0.0	12.9	290.9333	954.514
		N	—1.8972	0.0				
		Mean	—1.8972					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.2808692 8 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
*U. S. P. B. M. 22A from T. B. M. 127	156.43	S	−0.6776	+0.3	0.3	12.9	292.1532	958.516
		N	−0.6762	−1.1				
		N	−0.6780	−0.7				
		Mean	−0.6773					
T. B. M. 128 from T. B. M. 127	156.88	S	+0.6106	+0.3	0.2	......	293.4414	962.743
		N	+0.6113	−0.4				
		Mean	+0.6109					
T. B. M. 129	158.00	S	+1.1066	+1.3	0.5	......	294.5493	966.378
		S	+1.1092	−1.3				
		N	+1.1079	−0.0				
		Mean	+1.1079					
T. B. M. 130	158.92	S	−1.7970	+1.6	1.0	......	292.7539	960.487
		N	−1.7939	−1.5				
		Mean	−1.7954					
T. B. M. 131	159.89	S	−1.5316	+0.7	0.4	......	291.2230	955.465
		N	−1.5303	−0.6				
		Mean	−1.5309					
T. B. M. 132	161.40	S	+0.1140	−3.0	1.8	......	291.3340	955.829
		N	+0.1056	+5.4				
		N	+0.1135	−2.5				
		Mean	+0.1110					
T. B. M. 133	162.84	S	−2.3318	+6.4	1.5	......	289.0086	948.199
		N	−2.3223	−3.1				
		N	−2.3250	−0.4				
		S	−2.3226	−2.8				
		Mean	−2.3254					
T. B. M. 134	164.52	S	−2.9287	−0.7	0.5	......	286.0792	938.568
		N	−2.9301	+0.7				
		Mean	−2.9294					
U. S. P. B. M. 23 from T. B. M. 134*	164.71	S	−0.7810	−0.5	0.3	13.2	285.2977	936.024
		N	−0.7820	+0.5				
		Mean	−0.7815					
U. S. P. B. M. 23 A from T. B. M. 134*	164.71	S	+0.4353	−0.5	0.3	13.2	286.5140	940.015
		N	+0.4343	+0.5				
		Mean	+0.4348					
U. S. P. B. M. 24 from T. B. M. 134*	164.56	S	+0.2927	−0.2	0.1	13.2	286.3717	939.548
		N	+0.2923	+0.2				
		Mean	+0.2925					
Base of rail at Rush City depot from T. B. M. 134*	164.66	S	+0.1590	......	......	......	286.2382	939.110
T. B. M. 135 from T. B. M. 134	165.90	S	−0.0675	−1.2	0.8	......	286.0105	938.363
			−0.0698	+1.1				
		Mean	−0.0687					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 136	167.65	S	+ 0.1537	+ 2.2	1.3	......	286.1664	938.875
		N	+ 0.1629	− 7.0				
		S	+ 0.1524	+ 3.5				
		S	+ 0.1539	+ 2.0				
		N	+ 0.1566	− 0.7				
		Mean	+ 0.1559					
T. B. M. 137	168.87	S	− 0.1765	− 1.9	1.3	......	285.9880	938.289
		N	− 0.1803	+ 1.9				
		Mean	− 0.1784					
T. B. M. 138	170.42	S	− 0.5510	− 0.7	0.5	......	285.4363	936.479
		N	− 0.5525	+ 0.8				
		Mean	− 0.5517					
T. B. M. 139	171.65	S	− 0.5673	− 0.6	0.4	......	284.8684	934.616
		N	− 0.5685	+ 0.6				
		Mean	− 0.5679					
T. B. M. 141	173.12	S	− 0.2128	+ 1.5	1.0	......	284.6571	933.923
		N	− 0.2099	− 1.4				
		Mean	− 0.2113					
T. B. M. 142	174.63	S	− 0.6945	+ 0.6	0.4	......	283.9632	931.646
		N	− 0.6933	− 0.6				
		Mean	− 0.6939					
Base of rail at Harris depot from T. B. M. 142*	175.67	S	− 3.6547	......	......	......	280.3085	919.656
T. B. M. 143	175.78	S	− 3.3320	− 2.2	1.5	......	280.6290	920.707
		N	− 3.3364	+ 2.2				
		Mean	− 3.3342					
U. S. P. B. M. 25 from T. B. M. 143*	175.95	S	− 0.8204	+ 0.1	0.0	13.5	279.8087	918.016
		N	− 0.8203	0.0				
		Mean	− 0.8203					
U. S. P. B. M. 25 A from T. B. M. 143*	175.95	S	+ 0.3913	− 0.3	0.5	13.5	281.0200	921.900
		N	+ 0.3897	+ 1.3				
		N	+ 0.3920	− 1.0				
		Mean	+ 0.3910					
T. B. M. 144 from T. B. M. 143	177.12	S	+ 3.6631	0.0	0.0	......	284.2921	932.725
		N	+ 3.6631	0.0				
		Mean	+ 3.6631					
T. B. M. 145	178.68	S	+ 1.7256	+ 7.0	2.4	......	286.0247	938.410
		N	+ 1.7360	− 3.4				
		S	+ 1.7363	− 3.7				
		Mean	+ 1.7326					
T. B. M. 146	179.59	S	− 0.9350	+ 0.5	0.3	......	285.0902	935.344
		N	− 0.9340	− 0.5				
		Mean	− 0.9345					
T. B. M. 147	180.80	S	+ 2.9564	0.0	0.0	......	288.0466	945.043
		N	+ 2.9564	0.0				
		Mean	+ 2.9534					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		Meters.	Mm.	Mm.	Mm.	Meters.	Feet.
T. B. M. 148	182.15	S..... N.....	— 4.2324 — 4.2308	+ 0.8 — 0.8	0.5	......	283.8150	931.160
		Mean .	— 4.2316					
T. B. M. 149	182.99	S..... N.....	— 1.9576 — 1.9613	— 1.9 + 1.8	1.2	......	281.8555	924.731
		Mean .	— 1.9595					
U. S. P. B. M. 26 from T. B. M. 149	184.11	S..... N.....	— 3.0870 — 3.0904	— 1.7 + 1.7	1.1	13.8	278.7668	914.597
		Mean .	— 3.0887					
Base of rail at North Branch depot from P. B. M. 26*	184.23	S.....	+ 1.1083	....	....	......	279.8751	918.234
U. S. P. B. M. 27 from P. B. M. 26*	184.24	S..... N.....	— 0.4813 — 0.4806	+ 0.4 — 0.3	0.2	13.8	278.2859	913.020
		Mean .	— 0.4809					
U. S. P. B. M. 27 A from P. B. M. 26*	184.24	S..... N.....	+ 0.7385 + 0.7367	— 0.9 + 0.9	0.6	13.8	279.5044	917.017
		Mean .	+ 0.7376					
T. B. M. 150 from P. B. M. 26	185.62	S..... N..... N.....	+ 4.8841 + 4.8738 + 4.8832	— 3.7 + 6.6 — 2.8	2.2	......	283.6472	930.609
		Mean .	+ 4.8804					
T. B. M. 151 from T. B. M. 150	187.11	S..... N.....	— 1.5680 — 1.5728	— 2.4 + 2.4	1.6	......	282.0768	925.457
		Mean .	— 1.5704					
T. B. M. 151 A	187.74	S..... N.....	+ 1.5829 + 1.5797	— 1.6 + 1.6	1.1	......	283.6581	930.645
		Mean .	+ 1.5813					
T. B. M. 152	188.44	S..... N.....	+ 0.3600 + 0.3573	+ 1.4 — 1.3	0.9	......	284.0167	931.822
		Mean .	+ 0.3586					
T. B. M. 153	189.69	S..... N.....	— 2.2545 — 2.2546	— 0.0 + 0.1	0.0	......	281.7622	924.425
		Mean .	—2.2545					
T. B. M. 154	191.20	S..... N.....	+ 0.9804 + 0.9763	— 2.1 + 2.0	1.4	......	282.7405	927.635
		Mean .	+ 0.9783					
T. B. M. 155	192.30	S..... N.....	+ 1.7320 + 1.7281	— 2.0 + 1.9	1.3	......	284.4705	933.311
		Mean .	+ 1.7300					
T. B. M. 156	193.65	S..... N..... N.....	— 2.2226 — 2.2165 — 2.2211	+ 2.5 — 3.6 + 1.0	1.2	......	282.2504	926.027
		Mean .	— 2.2201					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 157	194.99	S	+ 0.4313	+ 1.9	1.2	......	282.6836	927.448
		N	+ 0.4350	− 1.8				
		Mean	+ 0.4332					
T. B. M. 158	196.97	S	− 4.2297	+ 0.1	0.1	......	278.4540	913.571
		N	− 4.2295	− 0.1				
		Mean	− 4.2296					
U. S. P. B. M. 28, from T. B. M. 158.*	197.07	S	− 0.6550	− 0.1	0.1	14.3	277.7989	911.422
		N	− 0.6553	+ 0.2				
		Mean	− 0.6551					
U. S. P. B. M. 28A, from T. B. M. 158*	197.07	S	+ 0.5593	− 0.1	0.1	14.3	279.0132	915.406
		N	+ 0.5594	− 0.2				
		N	+ 0.5590	+ 0.2				
		Mean	+ 0.5592					
T. B. M. 159, from T. B. M. 158	198.41	S	+ 2.1454	− 2.4	1.6	......	280.5970	920.602
		N	+ 2.1406	+ 2.4				
		Mean	+ 2.1430					
T. B. M. 160	199.76	S	− 0.0104	+ 3.4	1.2	......	280.5900	920.579
		N	− 0.0043	− 2.7				
		S	− 0.0063	− 0.7				
		Mean	− 0.0070					
T. B. M. 161	201.42	S	+ 2.3938	+ 1.8	1.2	......	282.9856	928.439
		N	+ 2.3974	− 1.8				
		Mean	+ 2.3956					
T. B. M. 162	202.66	S	− 0.9187	+ 1.1	0.7	......	282.0680	925.428
		N	− 0.9166	− 1.0				
		Mean	− 0.9176					
T. B. M. 163	203.66	S	− 1.3676	+ 1.0	0.6	......	280.7014	920.945
		N	− 1.3657	− 0.9				
		Mean	− 1.3666					
U. S. P. B. M. 29, from T. B. M. 163*	203.96	S	− 3.9963	− 0.8	0.5	14.5	276.7043	907.831
		N	− 3.9979	+ 0.8				
		Mean	− 3.9971					
U. S. P. B. M. 29A, from T. B. M. 163*	203.96	S	− 2.7813	+ 0.9	0.6	14.6	277.9211	911.823
		N	− 2.7796	− 0.8				
		Mean	− 2.7804					
Base of rail at Wyoming depot, from T. B. M. 163*	203.73	S	+ 0.1370	......	......	......	280.8384	921.394
T. B. M. 164, from T. B. M. 163	204.93	S	+ 4.3500	+ 0.5	0.4	......	285.0519	935.218
		N	+ 4.3511	− 0.6				
		Mean	+ 4.3505					
T. B. M. 165	206.50	S	− 0.2061	− 1.6	1.1	......	284.8442	934.537
		N	− 0.2093	+ 1.6				
		Mean	− 0.2077					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 166	207.65	S	− 2.4873	− 0.9	0.6	......	282.3560	926.373
		N	− 2.4890	+ 0.8				
		Mean	− 2.4882					
T. B. M. 167	209.04	S	− 2.1664	+ 1.4	0.9	......	280.1910	919.270
		N	− 2.1636	− 1.4				
		Mean	− 2.1650					
U. S. P. B. M. 30	210.42	S	+ 4.9306	− 4.2	1.4	14.7	285.1174	935.433
		N	+ 4.9247	+ 1.7				
		S	+ 4.9240	+ 2.4				
		Mean	+ 4.9264					
Base of rail at Forest Lake depot, from P. B. M. 30*	210.59	S	− 0.5300	......	......	......	284.5874	933.694
U. S. P. B. M. 31, from P. B. M. 30*	210.54	S	− 1.5780	+ 0.2	0.1	14.7	283.5396	930.256
		N	− 1.5777	− 0.1				
		Mean	− 1.5778					
U. S. P. B. M. 31A, from P. B. M. *	210.54	N	− 0.3533	− 0.9	0.4	14.7	284.7632	934.271
		S	− 0.3554	+ 1.2				
		S	− 0.3540	− 0.2				
		Mean	− 0.3542					
U. S. P. B. M. 32, from P. B. M. 30*	210.65	S	− 1.6284	− 0.1	0.1	14.7	283.4889	930.090
		N	− 1.6286	+ 0.1				
		Mean	− 1.6285					
U. S. P. B. M. 32A, from P. B. M. 30*	210.65	S	− 0.4133	+ 0.7	0.4	14.7	284.7048	934.079
		N	− 0.4120	− 0.6				
		Mean	− 0.4126					
T. B. M. 168 from P. B. M. 30	212.13	S	− 1.7524	− 1.5	1.0	......	283.3635	929.679
		N	− 1.7553	+ 1.4				
		Mean	− 1.7539					
T. B. M. 169	213.87	S	+ 5.1548	− 2.4	1.6	......	288.5159	946.583
		N	+ 5.1500	+ 2.4				
		Mean	+ 5.1524					
T. B. M. 170	215.58	S	+ 6.4360	− 2.2	1.5	......	294.9497	967.691
		N	+ 6.4316	+ 2.2				
		Mean	+ 6.4338					
T. B. M. 171	217.17	S	− 0.6622	− 0.1	0.0	......	294.2874	965.518
		N	− 0.6623	+ 0.0				
		Mean	− 0.6623					
T. B. M. 172	218.72	S	− 5.7307	+ 1.7	1.1	......	288.5584	946.722
		N	− 5.7273	− 1.7				
		Mean	− 5.7290					
T. B. M. 173	219.32	S	− 0.3330	+ 1.1	0.8	......	288.2265	945.633
		N	− 0.3307	− 1.2				
		Mean	− 0.3319					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	v.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 173 A	220.71	S	+ 1.3780	− 0.7	0.4	......	289.6038	950.152
		N	+ 1.3767	+ 0.6				
		Mean	+ 1.3773					
T. B. M. 174	221.56	S	+ 0.7516	+ 2.9	1.7	......	290.3583	952.628
		N	+ 0.7596	− 5.1				
		N	+ 0.7523	+ 2.2				
		Mean	+ 0.7545					
T. B. M. 174 A	223.03	S	+ 0.3533	− 0.6	0.4	......	290.7110	953.785
		N	+ 0.3521	+ 0.6				
		Mean	+ 0.3527					
T. B. M. 175	223.96	S	+0.3910	+2.3	1.0	......	291.1043	955.075
		N	+0.3963	−3.0				
		S	+0.3925	+0.8				
		Mean	+0.3933					
*U. S. P. B. M. 33 from T. B. M. 175	223.97	S	−0.8877	0.0	0.0	15.1	290.2166	952.163
		N	−0.8877	0.0				
		Mean	−0.8877					
*U. S. P. B. M. 33 A from T. B. M. 175	223.97	S	+0.3296	+0.4	0.3	15.1	291.4343	956.158
		N	+0.3293	+0.7				
		S	+0.3310	−1.0				
		N	+0.3300	−0.0				
		Mean	+0.3300					
*Base of rail at Centerville depot from T. B. M. 175	224.06	S	+0.1494	......	......	......	291.2537	955.565
T. B. M. 176 from T. B. M. 175	225.45	S	+0.8109	+1.2	0.8	......	291.9164	957.740
		N	+0.8133	−1.2				
		Mean	+0.8121					
T. B. M. 177	226.47	S	−1.3016	+0.3	0.2	......	290.6151	953.470
		N	−1.3010	−0.3				
		Mean	−1.3013					
T. B. M. 178	228.11	S	+2.3436	+0.8	0.6	......	292.9595	961.162
		N	+2.3453	−0.9				
		Mean	+2.3444					
T. B. M. 179	229.43	S	−5.8937	+1.0	0.7	......	287.0668	941.829
		N	−5.8917	−1.0				
		Mean	−5.8927					
T. B. M. 180	230.81	S	+3.0016	+1.2	0.8	......	290.0696	951.680
		N	+3.0040	−1.2				
		Mean	+3.0028					
*U. S. P. B. M. 34 from T. B. M. 180	230.83	S	−0.9440	+0.1	0.1	15.2	289.1257	948.584
		N	−0.9437	−0.2				
		Mean	−0.9439					
*U. S. P. B. M. 34 A from T. B. M. 180	230.83	S	+0.2690	+0.2	0.1	15.2	290.3388	952.564
		N	+0.2694	−0.2				
		Mean	+0.2692					

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Results of precise leveling Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
* Base of rail at St. P. & D., and M., St. Ste. M. & A. Ry. crossing at Bald Eagle depot, from T. B. M. 180	230.94	S	—00.390	......	......	......	290.0306	951.552
U. S. P. B. M. 35 from T. B. M. 180	232.56	S	+2.2166	+1.1	0.7	15.2	292.2873	958.956
		N	+2.2187	—1.0				
		Mean	+2.2177					
* U. S. P. B. M. 36 from P. B. M. 35	232.67	S	—0.9820	+0.1	0.1	15.2	291.3054	955.735
		N	—0.9817	—0.2				
		Mean	—0.9819					
* U. S. B. M. 36 A from P. B. M. 35	232.67	S	+0.2357	+0.7	0.3	15.2	292.5237	959.732
		N	+0.2350	+1.4				
		N	+0.2367	—0.3				
		S	+0.2866	—0.2				
		N	+0.2380	—1.6				
		Mean	+0.2364					
* U. S. P. B. M. 37 from P. B. M. 35	232.64	S	—1.0393	+0.2	0.1	15.2	291.2482	955.547
		N	—1.0390	—0.1				
		Mean	—1.0391					
* U. S. P. B. M. 37 A	232.64	S	+0.1750	+1.7	0.4	15.2	292.4640	959.536
		N	+0.1770	—0.3				
		S	+0.1770	—0.3				
		N	+0.1780	—1.3				
		Mean	+0.1767					
* Base of rail at White Bear depot from P. B. M. 35	232.66	S	—0.0080	......	......	......	292.2793	958.930
T. B. M. 181 from P. B. M. 35	234.39	S	—3.3257	—0.9	0.6	......	288.9607	948.042
		N	—3.3276	+1.0				
		Mean	—3.3266					
* U. S. P. B. M. 38 from T. B. M. 181	234.49	S	—0.6053	0.0	0.0	15.2	288.3554	946.056
		N	—0.6053	0.0				
		Mean	—0.6053					
U. S. P. B. M. 38 A from T. B. M. 181	234.49	S	+0.6140	—0.3	0.2	15.2	289.5744	950.056
		N	+0.6134	+0.3				
		Mean	+0.6137					
T. B. M. 182 from T. B. M. 181	235.52	S	+1.3991	—0.1	0.0	......	290.3597	952.632
		N	+1.3990	0.0				
		Mean	+1.3990					
T. B. M. 183	237.02	S	+0.5440	+0.6	0.4	......	290.9043	954.419
		N	+0.5451	—0.5				
		Mean	+0.5446					
T. B. M. 184	238.42	S	—4.1517	+1.6	1.1	......	286.7542	940 803
		N	—4.1484	—1.7				
		Mean	—4.1501					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.23086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 185	240.32	S	—5.2390	—2.7	1.3	......	281.5125	923.606
		N	—5.2474	+5.7				
		S	—5.2405	—1.2				
		N	—5.2401	—1.6				
		Mean	—5.2417					
T. B. M. 186	241.76	S	—3.8691	+2.0	1.4	......	277.6454	910.918
		N	—3.8650	—2.1				
		Mean	—3.8671					
U. S. P. B. M. 39	242.51	S	+1.7131	+2.6	1.3	15.4	279.3611	916.547
		N	+1.7195	—3.8				
		N	+1.7146	+1.1				
		Mean	+1.7157					
T. B. M. 187	242.68	S	+1.3960	+0.5	0.3	......	280.7576	921.129
		N	+1.3960	+0.5				
		S	+1.3974	—0.9				
		Mean	+1.3965					
*U. S. P. B. M. 39 A from T. B. M. 187	242.85	S	—0.1794	—0.2	0.1	15.4	280.5780	920.540
		N	—0.1797	+0.1				
		Mean	—0.1796					
* U. S. P. B. M. 40 from T. B. M. 187	242.75	S	—1.8213	+0.2	0.1	15.4	278.9365	915.154
		N	—1.8210	—0.1				
		Mean	—1.8211					
* U. S. P. B. M. 40 A from T. B. M. 187	242.75	S	—0.6113	—0.2	0.1	15.4	280.1461	919.123
		N	—0.6116	+0.1				
		Mean	—0.6115					
T. B. M. 188 from T. B. M. 187	244.35	S	—5.5802	1.8	1.2	......	275.1792	902.827
		N	—5.5767	—1.7				
		Mean	—5.5784					
T. B. M. 189	245.14	S	—2.1780	—4.3	1.4	......	272.9969	895.667
		N	—2.1845	+2.2				
		S	—2.1843	+2.0				
		Mean	—2.1823					
T. B. M. 190	246.15	S	—1.0847	—0.8	0.6	......	271.9114	892.106
		N	—1.0864	+0.9				
		Mean	—1.0855					
T. B. M. 191	247.53	S	—13.7130	—2.4	1.4	......	258.1960	847.107
		N	—13.7217	+6.3				
		S	—13.7139	—1.5				
		N	—13.7130	—2.4				
		Mean	—13.7154					
T. B. M. 191 A'	248.08	S	— 4.6620	+1.3	0.9	......	253.5353	831.816
		N	— 4.6594	—1.3				
		Mean	— 4.6607					
T. B. M. 192	249.30	S	—21.8657	+3.7	1.3	......	231.6733	760.090
		N	—21.8590	—3.0				
		S	—21.8613	—0.7				
		Mean	—21.8620					

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Results of precise leveling, Duluth, Minn., to St. Paul, Minn., May 1 to September 25, 1891—Continued.

[Bench marks marked thus * are not in the main line of levels. In these reductions the value of 1 meter is 3.28086928 feet.]

Bench marks.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation above Cairo datum.	
	Km.		*Meters.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 193	249.90	S	− 8.6586	−0.3	0.2	......	223.0144	731.681
		N	− 8.6593	+0.4				
		Mean	− 8.6589					
U. S. P. B. M. 68 of O. W. F.	251.08	S	− 2.5929	0.0	0.0	15.7	220.4215	723.174
		N	− 2.5929	0.0				
		Mean	− 2.5929					
U. S. P. B. M. 69 of (O. W. F.) ="old B. M. A."	251.23	S	+ 1.2170	−0.2	0.1	15.7	....	....
		N	+ 1.2166	+0.2				
		Mean	+ 1.2168					
*U. S. P. B. M. 71 (O. W. F.) from P. B. M. 68	251.18	S	+ 1.6712	−0.7	0.5	15.7	....	....
		N	+ 1.6698	+0.7				
		Mean	+ 1.6705					

DESCRIPTION AND ELEVATIONS OF PRECISE BENCH MARKS BETWEEN DULUTH AND ST. PAUL.

[NOTE.—Elevations are given in meters and feet above the Cairo datum plane. A P. B. M. is a precise bench mark which is set with special care so as to be practically permanent. A T. B. M. is a temporary bench mark whose elevation is as well determined as the P. B. M., but which is not regarded as specially permanent. To reduce to mean gulf level at Biloxi, Miss., subtract 21.26 feet (preliminary value) from the elevations here given. These bench marks were established in 1891. One meter=3.2808693.]

Duluth water gauge is a graduated board gauge fastened to the south pier of the canal connecting Lake Superior with the Bay of Duluth, at Duluth, Minn. It is 195 feet from the west end of the pier. By the records of the United States Engineers' office at Duluth the zero of the gauge is set at the "plane of 1873," which is approximately 601.24 feet above mean sea level. It is designated as gauge No. 18.

Elevation, 189.4599 meters. 621.593 feet.

B. M. 1 of U. S. Engineers at Duluth is the upper surface of the water table of Miller's Block, at the east corner of Lake avenue and Superior street, Duluth, Minn. It is 12 feet and 1 inch south of the corner of building, and on the Lake avenue side. Established in 1873.

Elevation, 197.2313 meters. 647.090 feet.

B. M. 19 of U. S. Engineers at Duluth is top of tack in square of black paint on top surface of cap, at north end of Graves Slip, in Duluth, Minn. Is about 2 feet from a snubbing post and 234 feet north of the first angle in the wharf. Was established in 1887.

Elevation, 191.3050 meters. 627.647 feet.

B. M. 23 of U. S. Engineers at Duluth is marked by square of black paint, 2 inches in diameter, and is top surface of granite pedestal supporting an iron post of the Sixth avenue viaduct, over the railroad tracks at Duluth, Minn. It is at the eastern end of the southern bent of posts, and is near the north line of Railroad street.

Elevation, 191.8815 meters. 629.538 feet.

B. M. in "Iron Bay Iron Works" building, is cross cut in office doorstep of "Iron Bay Iron Works" building, at West Duluth, Minn.; it is 6 inches from north jamb and 2 inches from front of step.

Elevation, 197.7750 meters. 648.874 feet.

U. S. P. B. M. No. 1 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is 522 feet northward from the West End depot, and 44 feet eastward from the St. Paul and Duluth Railway track. It is 59 feet southward from Railroad bridge No. 48, and about 5 miles southward from the Duluth Union depot.

Elevation, 199.6706 meters. 655.093 feet.

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U. S. P. B. M. 1 A. is top of iron cap on top of pipe over P. B. M. 1, described above.

Elevation, 200.8829 meters. 659.071 feet.

U. S. P. B. M. 2 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is 43 feet eastward of the St. Paul and Duluth Railway track, and 66 feet west of the public road leading from Duluth to Fond du Lac, and 1,476 feet northward from the depot at Smithville, St. Louis County, Minn. It is 156 feet northeastward from the railroad section house. There is an iron post projecting 6 inches above ground, 148 feet southward from the bench mark, and on which are the letters "St. P. & D. R. R." This post is said to be the northeast corner of SE. ¼, of NE. ¼ of sec. 27, T. 49, R. 15.

Elevation, 220.3716 meters. 723.010 feet.

U. S. P. B. M. 2 A is top of iron cap on top of pipe over P. B. M. 2, described above.

Elevation, 221.5849 meters. 726.991 feet.

U. S. P. B. M. 3 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is 52 feet north of the St. Paul and Duluth Railway track, 6,562 feet west of the St. Paul and Duluth Railway depot at Short Line Park, St. Louis County, Minn. It is at the east end of high embankment on the St. Paul and Duluth Railway, and is in southwest corner of a field.

Elevation, 297.4737 meters. 975.972 feet.

U. S. P. B. M. 3 A is top of iron cap on top of pipe over P. B. M. 3, described above.

Elevation, 298.6914 meters. 979.967 feet.

T. B. M. 25 is nail in root of stump 10 feet west of St. Paul and Duluth Railway track, and is 10 feet from station milepost, 1 mile north of Howell, Minn. This bench mark was established by some former survey.

Elevation, 338.0249 meters. 1,109.015 feet.

U. S. P. B. M. 4 is top of copper bolt, in vitrified clay slab in ground, and surmounted by iron pipe. It is 49 feet south of the St. Paul and Duluth Railway track, and 6,890 feet east of the depot at Thomson, Carlton County, Minn. It is 298 feet west of a cattle guard, and 2.5 feet north of the right of way south fence.

Elevation, 332.4313 meters. 1,090.664 feet.

U. S. P. B. M. 4 A is top of iron cap on top of pipe over P. B. M. 4, described above.

Elevation, 333.6433 meters. 1,094.640 feet.

U. S. P. B. M. 5 is cross cut on top of window sill of the Carlton County courthouse at Carlton, Minn. It is in the first window north of the tower and on the western side of the building. The bench mark is marked thus: U. S. + B. M.

Elevation, 338.2783 meters. 1,109.847 feet.

T. B. M. 39 is spike in root of pine tree 3 feet in diameter on eastern side of public road leading south from Carlton, Minn. It is about 2,950 feet north of the junction of the public road with the old military road leading from Superior to St. Paul.

Elevation, 344.8215 meters. 1,131.314 feet.

U. S. P. B. M. 6 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is 1 foot southward from the southern fence of the Superior and St. Paul Military road and on land of Michael O'Donnell, in Carlton County, Minn. It is 371 feet eastward from the northwest corner of sec. 1, T. 47, R. 17, and is 190 feet northward from O'Donnell's house, and is about 6 miles southward from the town of Carlton.

Elevation, 345.5067 meters. 1,133.562 feet.

U. S. P. B. M. 6 A is top of iron cap on top of pipe over P. B. M. 6, described above.

Elevation, 346.7206 meters. 1,137.545 feet.

U. S. P. B. M. 7 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is about 100 feet northward from the Military road and 500 feet westward from the bridge over Blackhoof River, and 8.5 miles eastward from Barnum, in Carlton County, Minn. There are two Norway pine trees blazed, respectively, 79 feet northward and 62 feet northeastward from the bench mark.

Elevation, 338.6807 meters. 1,111.167 feet.

U. S. P. B. M. 7 A is top of iron cap on top of pipe over P. B. M. 7, described above.

Elevation, 339.8991 meters. 1,115.165 feet.

T. B. M. 55 is spike in root of pine tree 3 feet in diameter, west of Military road, about 1,640 feet southward from farmhouse. The bench mark is on top of a hill where the road turns southward and is 3.4 miles southwestward from Blackhoof Bridge, in Carlton County, Minn.

Elevation, 371.5908 meters. 1,219.141 feet.

U. S. P. B. M. 8 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is 59 feet northwestward from the Military road and 193 feet northward from the junction of the Military road with public road leading to Barnum. The bench mark is 3.9 miles east of Barnum, in Carlton County, Minn.

Elevation, 361.4218 meters. 1,185.778 feet.

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U. S. P. B. M. 8 A is top of iron cap on top of pipe over P. B. M. 8, described above.
Elevation, 362.6318 meters. 1,189.748 feet.

U. S. P. B. M. 9 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is in the southeast corner of sec. 36, and is 17 feet northward from the township corner marking Ts. 46 and 47, Rs. 18 and 19, and being the northwest corner of T. 46, R. 18, in Carlton County, Minn. The township corner is marked by an iron bolt driven about 3 feet in the ground and is in the public road. The bench mark is about 1 mile east of Barnum depot.
Elevation, 366.3258 meters. 1,201.867 feet.

U. S. P. B. M. 9 A is top of iron cap on top of pipe over P. B. M. 9, described above.
Elevation, 367.5488 meters. 1,205.880 feet.

T. B. M. 59 is railroad spike in root of pine tree, 103.5 feet eastward from the threshold of the railway depot at Barnum, Carlton County, Minn.
Elevation, 340.7425 meters. 1117.932 feet.

T. B. M. 62 is railroad spike in root of poplar tree, 8 feet east of fence, 58 feet east of St. Paul and Duluth Railway track, 705 feet south of public road and railroad crossing, and about 3 miles south of Barnum, in Carlton County, Minn.
Elevation, 336.6038 meters. 1,104.353 feet.

U. S. P. B. M. 10 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is 20 feet 8 inches from the southeast corner of L. L. Sargeant's dwelling house, in Moose Lake, Carlton County, Minn. It is 145 feet eastward from the St. Paul and Duluth Railway track, and 282 feet eastward from the railway depot, and 525 feet eastward from a warehouse under which is the northwest corner of sec. 21, T. 46, R. 19.
Elevation, 329.1897 meters. 1,080.028 feet.

U. S. P. B. M. 10 A is top of iron cap on top of pipe over P. B. M. 10, described above.
Elevation, 330.4060 meters. 1,084.019 feet.

U. S. P. B. M. 11 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is 321 feet southward from the south side of the railway depot at Sturgeon Lake, Pine County, Minn., and 34 feet east of the St. Paul and Duluth Railway track. It is 209 feet southwestward from Cunningham's barn, on a steep hillside which slopes southeastward to the bed of a former lake.
Elevation, 331.6033 meters. 1,087.947 feet.

U. S. P. B. M. 11 A is top of iron cap on top of pipe over P. B. M. 11, described above.
Elevation, 332.8266 meters. 1,091.961 feet.

U. S. P. B. M. 12 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is on land of H. S. Akin, in Willow River village, Pine County, Minn. It is 3.3 feet west of the southwest corner of sec. 2, T. 44, R. 20; is 23 feet from each of two white pine witness trees to the section corner above named, and is 108 feet northeastward from Akin's house.
Elevation, 319.2809 meters. 1,047.519 feet.

U. S. P. B. M. 12 A is top of iron cap on top of pipe over P. B. M. 12, described above.
Elevation, 320.4954 meters. 1,051.504 feet.

U. S. P. B. M. 13 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe, on land of Hugh Conway, at Kettle River station, Pine County, Minn. It is 262 feet west of a point on the St. Paul and Duluth Railway track, which is 390 feet south of the railway depot. It is 32 feet west of a fence and 147 feet westward from the northwest corner of a school house.
Elevation, 320.2437 meters. 1,050.678 feet.

U. S. P. B. M. 13 A is top of iron cap on top of pipe over P. B. M. 13, described above.
Elevation, 321.4588 meters. 1.054.664 feet.

T. B. M. 86 is railroad spike in root of elm tree 1 foot in diameter, about 100 feet west of the St. Paul and Duluth Railway track and about 500 feet southwestward from Finlayson depot, Pine County, Minn.
Elevation, 343.8081 meters. 1,127.983 feet.

T. B. M. 90 is railroad spike in root of pine tree 18 inches in diameter, about 70 feet west of the St. Paul and Duluth Railway track and 1,100 feet north of the north headblock of the railway siding at Miller station, Pine County, Minn.
Elevation, 350.9045 meters. 1,151.272 feet.

U. S. P. B. M. 14 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is 45 feet east of the St. Paul and Duluth Railway track and 1,060 feet south of the railway section house at Miller station, Pine County, Minn. It is 60 feet southeastward from the east end of a wooden culvert under the railway track.
Elevation, 350.4838 meters. 1,149.892 feet.

U. S. P. B. M. 14 A is top of iron cap on top of pipe over P. B. M. 14, described above.
Elevation, 351.6959 meters. 1,153.868 feet.

U. S. P. B. M. 15 is top of copper bolt in vitrified clay slab in ground and sur-

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mounted by iron pipe. It is 121 feet west of the St. Paul and Duluth Railway track and 150 feet northwestward from the northwest corner of the railway depot at Sandstone Junction, Pine County, Minn.

Elevation, 347.2714 meters. 1,139.352 feet.

U. S. P. B. M. 15 A is top of iron cap on top of pipe over P. B. M. 15, described above.

Elevation, 348.4904 meters. 1,143.351 feet.

T. B. M. 99 is spike in root of pine stump, 2 feet in diameter, 30 feet west of St. Paul and Duluth Railway track, about 490 feet north of north end of railroad excavation, and 2.3 miles south of Sandstone Junction depot, in Pine County, Minn.

Elevation, 346.1816 meters. 1,135.777 feet.

U. S. P. B. M. 16 is a cross cut on top the granite bridge seat of the northeast corner of the trussed span of the St. Paul and Duluth Railway over Grindstone River at Hinckley, Pine County, Minn. It is 6 inches from the south face and 6 inches from the east face of the stone and 10 inches from the southeast corner of the bed plate under the inclined end post of the bridge. It is marked thus: U. S. + B. M.

Elevation, 319.9163 meters. 1,049.604 feet.

U. S. P. B. M. 17 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is in the northeast angle formed by the crossing of the St. Paul and Duluth, and the Eastern Minnesota Railways at Hinckley, Pine County, Minn. It is 123 feet northeastward from the center of the crossing, 48 feet northwestward from center of the Eastern Minnesota Railway, and 65 feet eastward from the center of the St. Paul and Duluth Railway.

Elevation, 320.2046 meters. 1,050.549 feet.

U. S. P. B. M. 17 A is top of iron cap on top of pipe over P. B. M. 17, described above.

Elevation, 321.4245 meters. 1,054.552 feet.

T. B. M. 108 is a railroad spike in root of maple tree 8 inches in diameter 65 feet east of St. Paul and Duluth Railway track and 580 feet northward from the north headblock of the railway siding at Mission Creek station, Pine County, Minn.

Elevation, 310.7197 meters. 1,019.431 feet.

U. S. P. B. M. 18 is top of copper bolt in vitrified clay slab in ground and surmounted by iron pipe. It is 46 feet east of the St. Paul and Duluth Railway track, 4.5 feet west of right of way fence and 2,600 feet south of the railway depot at Mission Creek, Pine County, Minn. There is an excavation in the railroad track at this point about 3 feet deep.

Elevation, 306.8203 meters. 1,006.637 feet.

U. S. P. B. M. 18 A is top of iron cap on top of pipe over P. B. M. 18, described above.

Elevation, 308.0406 meters. 1,010.641 feet.

T. B. M. 111 is railroad spike in top of poplar stump 4 inches in diameter, about 60 feet east of St. Paul and Duluth Railway track, 72 feet northeastward from railroad bridge No. 24, and 2.3 miles south of railway depot at Mission Creek, Pine County, Minn.

Elevation, 301.2404 meters. 988.330 feet.

U. S. P. B. M. 19 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is 71 feet westward from the north headblock of the railway siding at Browns Hill, Pine County, Minn.

Elevation, 302.8735 meters. 993.688 feet.

U. S. P. B. M. 19 A is top of iron cap on top of pipe over P. B. M. 19, described above.

Elevation, 304.0923 meters. 997.687 feet.

T. B. M. 188 is railroad spike in root of white pine tree 7 inches in diameter, 4.5 feet west of St. Paul and Duluth Railway track and about 160 feet northward from a 24 inch cast-iron culvert pipe under the railway track and 2 miles north of Pine City, Pine County, Minn.

Elevation, 298.5087 meters. 979.368 feet.

U. S. P. B. M. 20 is cross cut in top of east end of wall supporting the track stringers at the north end of the trussed span of the St. Paul and Duluth Railway over Snake River at Pine city, Pine County, Minn. It is 21 inches east of the east track stringer and 26 inches west of the west side of the inclined end post at the northeast corner of the span. It is marked thus: U. S. + B. M.

Elevation, 295.3348 meters. 968.955 feet.

U. S. P. B. M. 21 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is in the south side of Robinson Park at Pine City, Pine County, Minn.; is 4 feet north of the park fence, 59 feet west of the southeast corner of the park, 141 feet east of the southwest corner of the park, and 151 feet west of the St. Paul and Duluth Railway track.

Elevation, 294.5520 meters. 966.387 feet.

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U. S. P. B. M. 21 A is top of iron cap on top of pipe over P. B. M. 21, described above.

Elevation, 295.7728 meters. 970.392 feet.

U. S. P. B. M. 22 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. Is on land of E. Edgerton, at Brock Creek station, Pine County, Minn. It is 54 feet east of the St. Paul and Duluth Railway track, 53 feet southeastward from the southeast corner of railway bridge No. 18, and 243 feet southward from the railway depot. The bench mark stands near the edge of a small bluff, and is 265 feet westward from Edgerton's dwelling house.

Elevation, 290.9333 meters. 954.514 feet.

U. S. P. B. M. 22 A is top of iron cap on top of pipe over P. B. M. 22, described above.

Elevation, 292.1532 meters. 958.516 feet.

T. B. M. 132 is a railroad spike in root of poplar tree 9 inches in diameter, 60 feet west of St. Paul and Duluth Railway track, 2 miles north of Rush City, in Chisago County, Minn., and opposite the north end of the first railway curve north of Rush City.

Elevation, 291.3340 meters. 955.829 feet.

U. S. P. B. M. 23 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is in the Presbyterian churchyard at Rush City, Chisago County, Minn.; is 4 feet north of north wall of church and 65 feet from the northwest corner of the churchyard.

Elevation, 285.2977 meters. 936.024 feet.

U. S. P. B. M. 23 A is top of iron cap on top of pipe over P. B. M. 23, as described above.

Elevation, 286.5140 meters. 940.015 feet.

U. S. P. B. M. 24 is a cross cut in top of stone foundation of St. Paul and Duluth Railway, north of water tank at Rush City, Chisago County, Minn. It is on the northeast corner of the north pier of the third bent of frame work from the east side of the track and is about 4 inches from the corner of the stone. Is marked thus: U. S. +B. M.

Elevation, 286.3717 meters. 939.548 feet.

U. S. P. B. M. 25 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe at Harris Village, Chisago County, Minn. Is on the north end of a small knoll, 53 feet east of the St. Paul and Duluth Railway track and 55 feet west of the east fence of the public road; 849 feet southward from the railway depot and 206 feet eastward from S. J. Stark's dwelling house.

Elevation, 279.8087 meters. 918.016 feet.

U. S. P. B. M. 25 A is top of iron cap on top of pipe over P. B. M. 25, described above.

Elevation, 281.0200 meters. 921.990 feet.

T. B. M. 147 is a railroad spike in root of post-oak tree 10 inches in diameter. It is 58 feet east of the St. Paul and Duluth Railway track and 2 miles north of north Branch depot, Chisago County, Minn.

Elevation, 288.0466 meters. 945.043 feet.

U. S. P. B. M. 26 is a cross cut on top of stone foundation of the St. Paul and Duluth Railway water tank at north Branch, Chisago County, Minn. It is on the northwest corner of the second pier from north end, of second bent of frame work from the railway track, and is marked thus: U. S. + B. M.

Elevation, 278.7668 meters. 914.597 feet.

U. S. P. B. M. 27 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. It is 45 feet east of the St. Paul and Duluth Railway track and 711 feet south of the south line of Third street of North Branch Village, Chisago County, Minn., and is about 3 feet from the right of way fence.

Elevation, 278.2859 meters. 913.020 feet.

U. S. P. B. M. 27 A is top of iron cap on top of pipe over P. B. M. 27, described above.

Elevation, 279.5044 meters. 919.017 feet.

T. B. M. 152 is a cut spike in top of black-oak stump 6 inches in diameter, 80 feet east of the St. Paul and Duluth Railway track, near the north side of a large swamp, and 3 miles south of North Branch depot, Chisago County, Minn. The bench mark is about 100 feet north of the point where there is an offset of 10 feet in each right of way fence.

Elevation, 284.0167 meters. 931.822 feet.

T. B. M. 156 is a railroad spike in root of double oak tree, 6 feet east of fence, 56 feet east of St. Paul and Duluth Railway track, 240 feet north of a small bridge and 2 miles north of Stacey depot, Chisago County, Minn.

Elevation, 282.2504 meters. 926.027 feet.

U. S. P. B. M. 28 is top of copper bolt in vitrified clay slab in ground, and surmounted by iron pipe. Is on land of J. B. Dyarman, in Stacey Village, Chisago

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County, Minn. It is 179 feet west of the St. Paul and Duluth Railway track, 164 feet northwestward from the railway depot, and 13 feet north of the north side of Dyarman's dwelling house.

Elevation, 277.7989 meters. 911.422 feet.

U. S. P. B. M. 28 A is top of iron cap on top of pipe over P. B. M. 28, described above.

Elevation, 279.0132 meters. 915.406 feet.

T. B. M. 162 is a railroad spike in root of post-oak tree 8 inches in diameter, 6 feet east of fence, 56 feet east of St. Paul and Duluth Railway track, and 3,390 feet north of the railway depot at Wyoming, Chisago County, Minn.

Elevation, 282.0680 meters. 925.428 feet.

U. S. P. B. M. 29 is top of copper bolt in vitrified clay slab in ground and surmounted by iron pipe. It is on R. M. Fullerton's land in Wyoming Village, Chisago County, Minn. It is 70 feet east of the southeast corner of section 18, township 33 north, range 21 west, 139 feet east of the St. Paul and Duluth Railway track, 2 feet north of the north line of Fourth street and 1,100 feet north of the Wyoming Railway depot.

Elevation, 276.7043 meters. 907.831 feet.

U. S. P. B. M. 29 A is top of iron cap on top of pipe over P. B. M. 29, described above.

Elevation, 277.9211 meters. 911.823 feet.

U. S. P. B. M. 30 is a cross cut in top of foundation stone of St. Paul and Duluth Railway water tank at Forest Lake Village, Washington County, Minn. It is on the north pier of the second bent of framework from the railway track and is marked thus: U. S. + B. M.

Elevation, 285.1174 meters. 935.433 feet.

U. S. P. B. M. 31 is top of copper bolt in vitrified clay slab in ground and surmounted by iron pipe on the railroad reservation at Forest Lake, Washington County, Minn. It is 366 feet northwestward from a point on the St. Paul and Duluth Railway track which is on a line with the north side of the railway depot, and is 225 feet westward from the track, measured at right angles thereto.

Elevation, 283.5396 meters. 930.256 feet.

U. S. P. B. M. 31 A is top of iron cap on top of pipe over P. B. M. 31, described above.

Elevation, 284.7632 meters. 934.271 feet.

U. S. P. B. M. 32 is top of copper bolt in vitrified clay slab in ground and surmounted by iron pipe. It is in the northeast corner of lot 1, block 31, of Forest Lake Village, Washington County, Minn. Is 102.5 feet west of the St. Paul and Duluth Railway track and about 545 feet southwestward from the railway depot.

Elevation, 283.4889 meters. 930.090 feet.

U. S. P. B. M. 32 A is top of iron cap on top of pipe over P. B. M. 32, described above.

Elevation, 284.7048 meters. 934.079 feet.

T. B. M. 172 is a railroad spike in root of a double oak tree 14 inches in diameter, 6 feet west of right of way fence, 56 feet west of the St. Paul and Duluth Railway track, 430 feet southward from the point where the public road from Forest Lake to Centerville crosses the railway from the west to the east side of track, and about 3 miles north of Centerville, Washington County, Minn.

Elevation, 288.5584 meters. 946.722 feet.

U. S. P. B. M. 33 is top of copper bolt in vitrified clay slab in ground and surmounted by iron pipe, on Mrs. Frances Kitchliis' land, in Centerville, Washington County, Minn. It is 121 feet east of the St. Paul and Duluth Railway track, 7 feet north of an oak tree, 25 feet southward from the northwest corner of Mrs. Kitchliis' lot, and 187 feet northward from her store and dwelling house.

Elevation, 290.2166 meters. 952.163 feet.

U. S. P. B. M. 33 A is top of iron cap on top of pipe over P. B. M. 33, described above.

Elevation, 291.4343 meters. 956.158 feet.

T. B. M. 178 is a cut spike in root of oak tree 16 inches in diameter, 1 foot east of right of way fence and about 60 feet west of St. Paul and Duluth Railway track, and about 1.7 miles north of Bald Eagle Junction depot, Washington County, Minn. The bench mark is opposite the first curve and cut in the railway track south of Centerville.

Elevation, 292.9595 meters. 961.162 feet.

U. S. P. B. M. 34 is top of copper bolt in vitrified clay slab in ground and surmounted by iron pipe. It is 3 feet west of fence, 75 feet east of the St. Paul and Duluth Railway track, 410 feet northward from the Bald Eagle Junction depot, Ramsey County, Minn., and 449 feet northward from the crossing of the St. Paul and Duluth and the Minneapolis, Sault Ste. Marie and Atlantic railways.

Elevation, 289.1257 meters. 948.584 feet.

U. S. P. B. M. 34 A is top of iron cap on top of pipe over P. B. M. 34, described above.

Elevation, 290.3388 meters. 952,564 feet.

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U. S. P. B. M. 35 is a cross cut on top of the southeast corner of the foundation stone at the south end of the east bent under the north water tank of the St. Paul and Duluth Railway at White Bear, Ramsey County, Minn. It is 42 feet from the southwest corner of the pump house and 160 feet from the north end of the White Bear depot, and is marked thus: U. S. + B. M.

Elevation, 292.2873 meters. 958.956 feet.

U. S. P. B. M. 36 is top of copper bolt in vitrified clay slab in ground and surmounted by iron pipe. It is on lot 12, block 53, in White Bear village, Ramsey County, Minn. Is 37 feet east of the west line of Railroad avenue and 8 feet south of the south wall of the White Bear Hotel.

Elevation, 291.3054 meters. 955.735 feet.

U. S. P. B. M. 36 A is top of iron cap on top of pipe over P. B. M. 36, described above.

Elevation, 292.5237 meters. 959.732 feet.

U. S. P. B. M. 37 is top of copper bolt in vitrified clay slab in ground and surmounted by iron pipe. It is in the east side of "Railroad Park," White Bear, Ramsey County, Minn. Is 121 feet south of the south line of Fourth street, 207 feet from the northeast corner of the railway depot, and 85 feet from the northwest corner of a brick building now occupied by the Union meat market.

Elevation, 291.2482 meters. 955.547 feet.

U. S. P. B. M. 37 A is top of iron cap on top of pipe over P. B. M. 37, described above.

Elevation, 292.4640 meters. 959.536 feet.

U. S. P. B. M. 38 is top of copper bolt in vitrified clay slab in ground and surmounted by iron pipe. Is 1.2 miles south of White Bear depot, Ramsey County, Minn. Is 2 feet west of right of way fence, 46 feet east of the east track of the St. Paul and Duluth Railway, 302 feet northward from the headblock of the Minneapolis Branch of the St. Paul and Duluth Railway, and 315 feet northward from the switchman's house.

Elevation, 288.3554 meters. 946.056 feet.

U. S. P. B. M. 38 A is top of iron cap on top of pipe over P. B. M. 38, described above.

Elevation, 289.5744 meters. 950.056 feet.

T. B. M. 185 is a cross cut on top of the foundation stone of the first bent east of the St. Paul and Duluth Railway tracks at the second highway overbridge south of White Bear, Ramsey County, Minn. It is 13 feet 3 inches north of the south end of the mudsill foundation, and the bridge is 1.5 miles north of the Gladstone depot.

Elevation, 281.5125 meters. 923.606 feet.

U. S. P. B. M. 39 is top of copper bolt in vitrified clay slab in ground and surmounted by iron pipe. It is in the northwest angle formed by the crossing of the St. Paul and Duluth and the Wisconsin Central railways. Is 71 feet from the railroad (western) crossing, 33 feet west of the west track of the St. Paul and Duluth Railway, 153 feet westward from the southwest corner of the Buford plow factory, and about 550 feet northward from the St. Paul and Duluth Railway depot at Gladstone, Ramsey County, Minn.

Elevation, 279.3611 meters. 916.547 feet.

U. S. P. B. M. 39 A is top of iron cap on top of pipe over P. B. M. 39, described above.

Elevation, 280.5780 meters. 920.540 feet.

U. S. P. B. M. 40 is top of copper bolt in vitrified clay slab in ground and surmounted by iron pipe. It is in the northeast corner of the lot 11, block 2, of Gladstone Village, Ramsey County, Minn., and about 50 feet from the northeast corner of the Gladstone House, and 193 feet westward from the St. Paul and Duluth Railway.

Elevation, 278.9365 meters. 915.154 feet.

U. S. P. B. M. 40 A is top of iron cap on top of pipe over P. B. M. 40, described above.

Elevation, 280.1461 meters. 919.123 feet.

T. B. M. 189 is a spike in second cap from south end of Railroad bridge No. 4½ of the St. Paul and Duluth Railway, about 3.5 miles north of the St. Paul union depot. Is midway between the inside stringers of the two bridges (double track).

Elevation, 272.9969 meters. 895.667 feet.

T. B. M. 191 is a nail within a square cut on top of the south end of the foundation or mudsill of the east bent in second overbridge, about 2,625 feet south of the St. Paul and Duluth Railway depot at East Seventh street, St. Paul, Minn.

Elevation, 258.1960 meters. 847.107 feet.

T. B. M. 193 is a cross cut on top of the northern corner of the pedestal block supporting the southern post of the fourth bent of iron piers west of the St. Paul and Duluth Railway track, where it passes under the Third Street Viaduct in St. Paul, Minn.

Elevation, 223.0144 meters. 731.681 feet.

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U. S. P. B. M. 68 is in St. Paul, on the left bank of the Mississippi River, on lower wing wall of Kansas City and St. Paul Railway Bridge, 4.76 feet above the lower end of bridge-seat course, and 2.75 feet back from its front edge, being top of copper bolt leaded vertically, marked "U. S." ⊙ P. B. M.

Elevation, 220.4215 meters. 723.174 feet.

NOTE.—The Duluth-St. Paul line of precise levels and that of Assistant O. W. Ferguson, running from St. Paul southward, were connected at U. S. P. B. M.'s, Nos. 68, 69, and 71.

APPENDIX 4 D.

REPORT OF ASSISTANT ENGINEER F. B. MALTBY ON TOPOGRAPHICAL AND HYDROGRAPHICAL FIELD WORK FROM ALTON, ILL., TO HANNIBAL, MO.

ST. LOUIS, *January 25, 1892.*

CAPTAIN: I have the honor to submit the following report on the work done by the topographical and hydrographical party under my direction during the field season of 1891. On July 28 the U. S. S. *Patrol* and quarter-boat *Illinois* were turned over to me at New Boston, Ill., and started for St. Louis the same day. In accordance with your instructions a pipe boat, to be used as a fuel barge, was procured of Maj. Ruffner at Quincy. The quarter-boat *Illinois* was left at Alton, and the *Patrol*, with barge in tow, arrived at St. Louis August 1. After having the barge calked, and having taken on coal and supplies, and with the assistants who had been assigned to the party on board, the *Patrol* left St. Louis August 3, arriving at Alton the same day. Work was begun August 4, with the following organization of the party: F. B. Maltby in charge; topographers, A. T. Morrow, W. G. Comber, George H. French, O. W. Connett, E. J. Thomas, and Horace Dunnaway; hydrography, E. L. Harman, assisted by L. D. Cabanne; ordinary levels, O. N. Axtell and C. L. Ockerson; draftsman, M. I. Powers. T. C. Hockridge acted as master of the steamer, with William Kelly pilot and W. E. Mead engineer; 1 cook, 1 steward, 1 baker, and 2 waiters, 8 recorders, 1 leadsman, and 1 fireman, with from 25 to 30 laboring men. After about September 1 Mr. Harman was transferred to topography, and the sounding was done by Messrs. Hockridge and Cabanne. The party was quartered and subsisted on the *Patrol* and *Illinois*. No steam launch or small tug was furnished for taking the parties to and from their work; but, owing to slack current and to the *Patrol* being moved often, no inconvenience or serious delay was experienced. The boats were moved twenty times during the season, an average distance of 4.7 miles at each move. Steam was not raised on the *Patrol* except for moving, and then generally only for about two hours' time, so that the fuel consumption was small.

Work was begun on stone line No. 61, at the upper limits of Alton, Ill., where the field work, under Assistant Engineer C. M. Winchell, in 1889, ended. The work for the season was completed to stone line No. 94, at the upper limits of Hannibal, Mo., on November 13, and the party was disbanded. The party was in the field one hundred and three days, and almost exactly 100 miles of river (measured midway between banks) was covered by the survey, an average of about 1 mile per day, including Sundays, of which there were fourteen. The stage of the river and the weather were most favorable for surveys. The river was unusually low during the entire season and reached the lowest stage since 1864, thus permitting a very complete survey of the bars. During the entire season there were only two rainy days on which no fieldwork was done, and not more than four or five on which work was seriously delayed by bad weather. The health of the party was excellent during the season and no serious case of sickness occurred. The character of the river and the country adjoining is entirely different from that of any heretofore covered by the surveys under the Mississippi River Commission. Above the mouth of the Missouri River the banks are stable, the current very much less, and the amount of sediment in suspension insignificant compared with that in the Missouri River. In consequence radical changes in the channel line or banks are rare, and a map based on careful surveys will be valuable as showing the actual conditions and location of topographical features for a number of years. From Alton to Grafton the river flows along the foot of the Piasa Bluffs on the Illinois side. These famous bluffs have an average elevation of about 250 feet above the water and rise in many instances from near the high-water line from 75 to 125 feet in vertical cliffs. Just above Grafton is the mouth of the Illinois River, with a valley about 4½ miles wide. Above this the river follows along the Illinois Bluffs to Hamburg Bay and from here it crosses to the Missouri Bluffs at Clarksville, Mo., and from this point continues

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near the Missouri Bluffs to Hannibal. From the month of the Illinois River and running upstream there is an almost continuous line of islands of generally small size with the channel line crossing back and forth between them. From Clarksville south the bottom lands on the Missouri side are generally subject to overflow, and in consequence there are large tracts of land which are not cultivated. There has been no effort made to protect these tracts by levees except in local cases and by individuals, and these are usually of small extent. Extending along the Illinois shore from near Quincy, where the river again crosses to the Illinois Bluffs, tó the head of Hamburg Bay and from the bluffs to the river lies a tract of land containing about 170 square miles known as the Sny Island levee district, which is organized under the laws of Illinois. A levee averaging 8 feet in height has been built along the entire river front, a distance of 52 miles, and at a total cost of about $950,000. An area of 110,000 acres is protected by this levee, nearly all of which is made tillable thereby and is valued at an average of from $25 to $30 per acre, while that below Clarksville, which is subject to overflow and not protected, is valued at from $2.50 to $6 per acre.

Tertiary triangulation.—The topography is based on a system of secondary triangulation executed during 1881 under the Mississippi River Commission. Above Grafton, Ill., the system was carried across Calhoun Point to the vicinity of Martins Landing, and above that point the stations are on the bluffs on each side of the river valley, generally long distances apart. In consequence it was decided to carry a continuous tertiary system above Grafton. This system was started on a secondary line and connected with secondary stations wherever possible. Where secondary lines were not readily available the system was checked on tertiary bases. These bases were usually measured on sand bars, where there were no obstructions to careful chaining and where changes in elevation were slight. The measuring was done with a 20-meter chain, which was compared in each case with two standard meter bars belonging to this office. An approximate reduction for temperature was made. The system was laid out so that the lines could be seen over with little or no cutting, and stations placed as conveniently for the topographers as possible. The station points were marked with a pole cut on the ground, bearing a red and white flag. Angles were read with instrument Gambey No. 2, reading to 5 seconds. The instrument was mounted on an ordinary observing tripod, which was centered over the hole after removing the flag pole. Flags were set and angles read as much in advance of the topographers as possible in order to furnish them with azimuths and to check their work. Computation of triangles were made and plane coördinates worked out as fast as angles were read, and stations plotted before stadia stakes were put on the field sheets. Stations were erected and angles read by Mr. Morrow. Two hundred and thirty-six tertiary stations were occupied. The longest tertiary line was 9,739 meters and the shortest 411 meters in length. The average length was 1,528 meters. Below is given a tabulated result, showing the errors in closing on tertiary bases and secondary sides.

Results of tertiary triangulation.

	Miles of river.	Number of triangles.	Computed tertiary length.	Measured tertiary base.	Length of secondary side.	Ratio of error.
From △ 1 and △ 2—						
To Ⓐ Grafton Ⓐ W. Base	9	14	3,964.18	....	3,960.66	1:1125
To △ 34 △ 36	10	25	970.79	970.93	....	1:6935
To Ⓐ Keel Ⓐ Cahill	10	23	4,862.33	....	4,862.89	1:8684
To △ 74 △ 76	9	22	793.96	793.77	....	1:4179
Tó Ⓐ Hamburg Ⓐ Saltpeter	10	28	9,661.70	....	9,656.13	1:1734
To △ 127 △ 129	14	28	846.98	846.88	....	1:8470
To Ⓐ McLean Ⓐ Louisiana	8	19	7,096.21	....	7,097.23	1:6958
To Ⓐ Hannibal Ⓐ Seehorn	26	77	9,418.01	....	9,407.05	1:875

Average error, 1:4870.

Topography.—The general scope of the topographical work was in accordance with printed instructions. A continuous stadia line was run along each bank of the river, from which were taken the outlines of the bars and sufficient elevations for developing contours, the top and bottom of main banks, sounding flags, and such other features as could be reached. These lines were connected with and checked on triangulation stations. From these lines such lines were run back into the country as were necessary to develop contours and locate the natural and artificial features. In timbered country these side lines were run from 500 to 600 meters apart and in cleared country somewhat farther apart, and were generally run so as to form a circuit returning to the river and joined to some shore-line stake. Differences of elevation

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were determined by vertical angles. In timbered country the compass was very generally used. On the bluffs the area surveyed covered a belt averaging one-half mile wide from the river, in wooded country three-quarters mile, and in cleared country 1¼ miles in width. In addition the following features which come outside the above-mentioned limits were located: The bluff line from St. Charles, Mo., at the upper limit of the survey of the Missouri River Commission to Clarksville, Mo., a distance of 50 miles; the Illinois River and bluff line on each side of the valley for a distance of 10 miles from its mouth; the bluff line from Hamburg Bay to Ⓐ Seehorn opposite Hannibal, a distance of 40 miles; the "Sny" from opposite Hannibal to its mouth at Hamburg Bay, and a number of lakes and waterways lying between the bluffs and limits of topography. Owing to the very large number of islands the amount of topography per mile of river is very much increased over that below the mouth of the Missouri River. A record was kept showing the errors in stadia lines in closing on points of known position, both in distance and azimuth. From this record the following results are obtained: Errors in distance were obtained in 165 cases, covering a total distance of about 325 miles; the average length of lines compared is 3,150 meters; average error, including errors in plotting, is 3.6 meters, or 1 in 875. These comparisons include compass and side lines as well as shore line. Azimuths were compared one hundred and fifteen times, showing an average error of 2.4 minutes.

Owing to the pleasant weather which prevailed during the entire season, and as it was not thought advisable to keep the topographers on board to keep up the details of their work on the field plats, the draftsman was unable to plot much more than the stadia stakes and keep up with the field work. At the time of disbanding the party very few details had been put on the field plats and the topographers who were retained in the office have since been engaged in putting them on. As it is very desirable that the field plats be worked up and completed as soon after the field work as possible, and as the topographical work above Hannibal, in order to be done during the low-water season, will have to be done during the late summer and fall, when dry and pleasant weather is probable, I would suggest that to a party of the above size another draftsman be added. He should be one who has had experience in topographical work.

Levels.—A continuous line of ordinary levels was run on each side of the river connecting with and checking on the P. B. Ms. established in 1881 by the Mississippi River Commission. From Alton to Clarksville the P. B. Ms. are on the Illinois side and above Clarksville on the Missouri side. They were usually found and in good condition. All elevations were referred to Memphis datum. Below is given a table showing discrepancies between precise and ordinary levels. The algebraic sum of these errors is — 0.372 foot which is the error for 100 miles of river. The list also shows the numbers of the P. Ms. which were found and in good condition.

Discrepancies between precise and ordinary levels.

Between P. B. Ms.	Distance.	Error.	Leveled by—	Between P. B. Ms.	Distance.	Error.	Leveled by—
	Miles.				*Miles.*		
8 and 5	10.5	−0.186	C. L. Ockerson.	35 and 33	6.5	+0.020	C. L. Ockerson.
5 and 4	4.0	+0.016	Do.	33 and 31	5.5	+0.110	Do.
3 and 2	1.5	−0.028	Do.	31 and 29	6.5	−0.060	Do.
2 and 47	6.0	−0.069	Do.	28 and 24	9.6	+0.020	O. N. Axtell.
47 and 46	2.0	+0.147	Do.	24 and 23	1.0	−0.065	Do.
46 and 45	2.7	−0.077	Do.	23 and 20	10.4	+0.080	Do.
45 and 44	3.0	+0.072	Do.	20 and 19	2.5	−0.080	Do.
44 and 43	2.0	+0.143	Do.	19 and 18	5.4	−0.135	Do.
43 and 42	2.7	−0.052	Do.	18 and 17	6.0	+0.060	Do.
42 and 40	6.0	−0.168	Do.	17 and 16	2.2	+0.020	Do.
40 and 38	3.2	−0.100	Do.				
38 and 35	9.2	−0.040	Do.	Total	......	−0.372	

Lines of levels on opposite sides of river were checked on each other by making a river crossing about once in 3 miles usually at stone lines. River crossings were made by both observers taking 10 simultaneous readings to a rod across the river, the observers being on opposite banks. The observers then changed position and the operation repeated. A mean of all readings, was taken as the final value. Below is given a list of discrepancies between the right and left bank levels. The errors of the river crossings are included. The average error is 0.101 foot.

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Discrepancies between right and left bank levels.

Crossing at—	Distance.	Discrepancy.	Crossing at—	Distance.	Discrepancy.
	Miles.			*Miles.*	
Stone line 62	3	0.142	Stone line 77	3	0.080
63	3	0.002	78	3	0.017
64	3	0.191	80	6	0.094
65	3	0.164	81	3	0.179
66	3	0.176	82	3	0.097
67	3	0.067	84	6	0.050
68	3	0.121	85	3	0.087
69	3	0.052	87	6	0.180
70	3	0.064	88	3	0.032
71	3	0.203	89	3	0.180
72	3	0.080	90	3	0.000
73	3	0.060	91	3	0.049
74	3	0.152	92	3	0.105
75	3	0.200	93	3	0.050
76	3	0.064			

High-water marks were connected with whenever the marks were well defined and the information concerning them and the date was considered thoroughly reliable. The following list shows the number connected with and the year and elevation:

High-water marks, Alton to Hannibal.

Locality and description.	Year.	Elevation.
Alton mark cut in stone southeast corner Vinegar Works	1883	431.8
Alton mark painted on southeast corner of Vinegar Works	1888	427.8
Opposite Clifton, Ill., on third house below head of Dressers Island	1883	431.6
Jersey Landing, Illinois, mark on door frame brick building now used as depot	1844	442.3
Do	1858	440.3
Jersey Landing, Illinois, mark on warehouse just below flour mill	1858	440.3
War Eagle Landing, Missouri, on warehouse at landing	1883 1888	436.0
Head of Peruque Island, mark on gauge	1888	441.9
West Point Landing, Illinois, nail in tree in front of warehouse	1888	445.7
Cap-au-Gris, Missouri, notch in Locust tree	1888	445.2
Hamburg, Ill., cut in stone foundation of C. E. Rose's store	1888	452.0
Clarksville, Mo., mark cut in stone chimney of Phar's sawmill	1851	462.3
Do	1858	460.3
Do	1888	457.8
Louisiana, Mo., cut in stone in second pier of Chicago and Alton Railroad bridge	1888	462.3
Louisiana, Mo., cut in foundation of water works engine house	1851	466.4
Hannibal, Mo., cut in draw pier of Wabash Railroad bridge	1888	470.0

All water gauges were connected with and the elevation of the water surface at each sounding flag determined.

Stone lines were established as heretofore at intervals of about 3 miles. The form of bench mark of 1891, consisting of vitrified tile surmounted by iron pipe, was used and has given the best of satisfaction. While it was the intention so far as possible to put the bench marks in a straight line normal to the river, more attention was paid to locating the bench marks where they will probably not be disturbed and can be easily found, even if the location put them on one side of the established line. Where the bluffs were close to the river only one stone was put in on the bluff side. Thirty-three stone lines were established on which there are 107 bench marks.

Hydrography.—A section of the river was sounded about every 250 meters, soundings being taken every fifteen seconds and every third or fourth sounding located by two sextant angles read to located points on shore. A longitudinal line was also sounded which passed as near as possible through the deepest water on each section. This line was sounded with the boat floating with the current or with very little headway. On shallow lines several longitudinal lines were sounded to determine the least channel depth. In water less than 10 feet deep a sounding pole divided to feet was used and in greater depths a lead and line were used. A continuous record of the stage of the river was kept from a gauge at the quarter boats which was read three times a day. The elevation of the zero of the gauge was determined at each location. A section was sounded along the axis of the bridges at Louisiana and Hannibal and the elevation of the bottom of the bottom chord and distance above the water determined. This elevation at Louisiana is 473 feet, and is 28.7 feet above

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the zero of the gauge; at Hannibal the elevation is 488 feet, and is 31.6 feet above the zero of the gauge. The gauges in each case are on the bridge. Eight hundred and fifty-three sections of the river were sounded. The greatest channel depths found were 36 feet at Hannibal bridge, and 34 feet just above Alton. Least channel depths found were 3¼ feet at Mosier's Landing and Tisdale's towhead. The greatest depth of water found was 66 feet just below the east pier of the Louisiana bridge.

To the efficiency and hearty good will of my assistants is due the success of the season's work, and I am pleased to commend them most heartily as competent, energetic, and faithful workers, and to thank them personally for their friendliness.

Very respectfully,

F. B. MALTBY,
Assistant Engineer.

Capt. CARL F. PALFREY,
Corps of Engineers, U. S. A.

APPENDIX 4 E.

REPORT OF ASSISTANT ENGINEER A. T. MORROW ON CAVING BANKS AND CONDITION OF SURVEY MARKS FROM CAIRO TO DONALDSONVILLE, LOUISIANA.

ST. LOUIS, MO., *April 16, 1892.*

CAPTAIN: I have the honor to make the following report of the operations of the party which has been under my charge for the last three months:

The party was organized with Assistant Engineer F. B. Maltby in charge, who, with four assistants and a crew of about twenty men, quartered on the steamer *Patrol*, began operations at Cairo, Ill., on November 20, 1891, the object of the expedition being to make surveys of the caving bends and to inspect the marks of previous surveys from that point to Donaldsonville, La.

The work had progressed as far as Commerce Landing, 40 miles below Memphis, when on January 1 the steamer *Patrol* was caught in a gale and sunk. The party was then transferred to the steamer *Kerns* and resumed work on January 8.

On January 16 I joined the party at Helena, Ark., and succeeded Mr. Maltby, who had offered his resignation. From that point the work proceeded without interruption to Donaldsonville, La., where on March 22, in obedience to your orders, I discharged a part of my force and returned with one assistant and a small force of men to complete some fragmentary portions of work on bench marks which had been omitted on account of snow, and in order to properly balance the duties of the force.

The work was entirely completed on April 6, and on April 11 I reached Cairo where I turned over the property and discharged the remainder of my men. During the progress of the work the field notes of each day were platted on the succeeding day, and the plats were forwarded to the office as opportunity offered.

In the start only the portions of the river bank which had undergone change were surveyed, but, as it afterwards proved, it could not always be determined on the ground whether or not changes had taken place since the old surveys; and as such determinations surely could not be made in advance of the work, the topographical work developed into a complete survey of the bank lines of the river, the concave portions being surveyed with transit and stadia, with frequent connections on old survey marks, and the opposite bank by intersections at points as frequent as required in view of the constant changes occurring with the varying stages of water.

In advance of the shore-line parties two parties of stone hunters were kept at work in order to furnish connections for the topographers and to redescribe or replace such old survey marks as were still in existence. This work proved to be the more laborious part of our duties, and it often became necessary to call upon the shore-line parties for assistance, thus considerably extending the time that would have been necessary to do the shore-line work alone.

The result of the search for marks of the old surveys are as follows:

Entire number of ordinary bench marks looked for were 920, of which 635 were found.

Entire number of precise bench marks looked for were 130, of which 70 were found.

Entire number of triangulation stations looked for were 410, of which 101 were found.

Entire number of marks of all classes looked for were 1,460, of which 806 were found.

Entire number of marks caved in the river	180
Entire number of marks covered by sedimentary deposit and levees	127
Entire number of marks which have been dug up	37
Entire number of marks broken or otherwise destroyed	32
Entire number of marks not accounted for	255

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Probably a large percent of the marks not accounted for could be found with sufficient search, and many of those covered by sedimentary deposit could be restored by sufficient labor. Enough marks, however, have been found in all localities to furnish connections for future surveys.

The small number of triangulation stations remaining is due to the fact that they were generally placed near the banks and have been destroyed by the changes of the river. Of the various kinds of bench marks established by the old surveys, the flat stone and iron pipe are unquestionably the best. The pipes standing well above the surface are easily found and have seldom been covered by the sedimentary deposits which so completely conceal a large number of stones and cement posts.

Precise bench marks consisting of copper bolts in brick chimneys and brick foundations have not been well preserved, a large per cent of them having been destroyed by improvements or changes in the buildings, which are largely of a temporary character in those localities. A large per cent of the marks placed on or near levees have either been buried under additions or have been destroyed by other changes or improvements. Marks which were placed by the side of public roads or along land lines seem to have been best preserved. The changes that have taken place in the river are so varied and apparently so devoid of uniformity that any opinions in regard to them which were formed on the ground at the time of the survey would not be of value in comparison with conclusions derived from a subsequent study of the maps of the surveys.

The distance from Cairo to Donaldsonville by river is about 880 miles, and the whole time consumed by the expedition from its departure to its return was one hundred and forty-one days. Deducting the time lost by the wreck and consumed by the return trip, the time required for the survey (including Sundays and days lost by bad weather) was one hundred and fourteen days, showing an average daily progress of 7.7 miles. The work of the survey was considerably retarded by the work of searching for stones, and consequently the rate of progress was considerably below that which could have been made by the survey alone; but is sufficient to illustrate with what facility such surveys can be made by transit and stadia when untrammeled and in the hands of skilled topographers.

Very respectfully, your obedient servant,

A. T. MORROW,
Assistant Engineer.

Capt. CARL F. PALFREY,
Corps of Engineers, U. S. A.

APPENDIX 4 F.

REPORT OF ASSISTANT ENGINEER J. A. OCKERSON ON CAVING BANKS FROM CAIRO TO DONALDSONVILLE, WITH TABULATED RESULTS AND PLAT.

OFFICE MISSISSIPPI RIVER COMMISSION,
St. Louis, Mo., May 31, 1892.

CAPTAIN: I have the honor to submit the following tabulated results derived from a study of the recent caving-bank survey of the Mississippi River from Cairo to Donaldsonville, and a comparison of the same with previous surveys.

In order to make a ready and accurate comparison, the shore line of the survey of November, 1891, to March, 1892, was platted on the detail charts of the old surveys, mostly made from 1879 to 1883, and the area between the shore lines was carefully measured with a planimeter. This gave the area of caving.

The data for the depth of caving was derived from the old detail charts, which show the height of bank above datum, elevation of water surface, and depth of water. From this the height of the bank above the bed was easily deduced. Where the river had maintained its width and the channel lay close to the caving bank the height of the bank deduced was measured from the deepest part of the bed to the top of the bank. Where the channel lay some distance from the bank and the caving had widened the stream without shifting the channel materially, then the average depths between the thalweg and the depth near shore were taken as the depths of the bed and the heights of banks deduced accordingly.

The dates of the surveys of each section considered are given in the table and from them the average amount of erosion per annum was derived.

An inspection of the maps shows that caving rarely occurs on both banks of the river at the same time in the same locality. It shifts from bank to bank, and as it ceases on one side it begins on the other, so that the caving areas often slightly overlap each other. The total length of caving banks from Cairo to Donaldsonville, a midstream distance of 885 miles, is 921 miles. About 15 miles of this pertains to islands.

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With a very few exceptions there is more or less caving in all of the bends, but the amount of caving does not seem to bear any definite relation to the curvature. The maximum caving occurs in comparatively straight reaches, such as Leota, Raleigh, Milliken, Carlyle, Oak Bend, etc., while the extraordinary bends above Greenville show caving far below the maximum. Darnell Point, 80 miles from Cairo, is an example of excessive caving in a long, straight reach of river.

The annual erosion per mile of river reaches its maximum in the vicinity of Raleigh. In the vicinity of Oak Bend, below Vicksburg, it reaches nearly the same amount. After passing Natchez the erosion becomes rapidly less and from the Red River down it is quite small in amount.

The character of vegetation on the banks has no apparent influence on the extent of the erosion. In a caving bend which is partly cultivated and partly timbered the shore line curve is smooth and regular, showing that they are eroded with equal facility.

Of 37 localities between Cairo and Vicksburg where depths of less than 10 feet were reported in 1891, 21 were found to be at the foot of or immediately below rapidly caving banks.

The amount of erosion given in these tables is doubtless considerably less than the total movement. In some localities where rapid caving was going on at the time when the first surveys were made now we find a heavy fill.

Opposite Commerce, Miss., is a case of that kind, where a caving bank in 1879 has filled about 2,000 feet in width and about 5 miles long, a part of which is now cultivated.

It is not improbable that there are places where the process of scour and fill has been repeated several times during the intervals between the surveys. The total movement by erosion would probably exceed the amount given in tables by about 15 per cent.

The average annual amount of erosion, as derived from the tabulated results, is found to be about 9½ acres in area by 66 feet deep for each mile of river; or a total for the river between Cairo and Donaldsonville of 10 square miles by 86 feet in depth annually.

Erosion does not necessarily mean a widening of the bed of the river. The eroded bank is generally followed by an equivalent fill on the opposite bank, and in some localities of excessive erosion the bed has actually grown narrower.

The composition of the banks is not given in sufficient detail to determine the relation, if any, between character of banks and erosion. In the region of excessive caving the banks are largely composed of sand. In some localities, where the banks are described as being clay, the erosion has been slight.

Respectfully submitted.

J. A. OCKERSON,
Assistant Engineer.

Capt. CARL F. PALFREY,
Corps of Engineers, U. S. A.,
Secretary.

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Table of caving banks between Cairo and Donaldsonville.

[NOTE.—The caved areas were carefully measured from the maps with a planimeter. The average depth of caved areas was derived from the detailed maps which show heights of banks above bed of the river.]

Right or left bank.	Locality.	Dates of surveys.	Distance from Cairo.	Length.	Average width.	Average depth.	Total area of caving.	Total volume of caving.	Character of bank.		Caving per annum.	
									Soil.	Vegetation.	Area.	Volume.
			Miles.	*Yards.*	*Yards.*	*Yards.*	*Sq. yards.*	*Cubic yards.*			*Sq. y'ds.*	*Cu. yards.*
R. B ...	Birds Point and bend above	Dec., 1876–Nov., 1891	1.5	7,000	362.5	13.5	2,646,000	35,721,000	Sand	0.1 cultivated..	178,000	2,397,000
L. B ...	Bar, etc., southwest of Cairo....	....do	0.6	5,000	314.4	8.0	1,572,000	12,576,000	....do	Timber	106,000	844,000
L. B ...	Upper part of Island No. 1 and bend above.	....do	4.5	6,140	124.4	13.0	764,000	9,932,000	Sand and clay.	....do	51,000	667,000
R. B ...	Norfolk Landing	Nov., 1879–Nov., 1891	8.3	4,280	117.8	20.2	504,000	110,181,000	....do	0.3 cultivated..	42,000	848,000
R. B ...	Lucas Bend and point below to Belmont.	....do	17.0	14,200	110.7	20.3	1,572,000	31,912,000	Sand	....do	131,000	2,659,000
L. B ...	Columbus and below............	....do	23.0	8,130	30.6	19.0	244,000	4,636,000	(?)	Cultivated	21,000	392,000
R. B ...	Beckwiths Bend	....do	32.0	7,280	237.6	20.0	1,730,000	34,600,000	Sand and clay.	0.1 cultivated..	145,000	2,908,000
R. B ...	Foot of Island No. 6............	....do	37.8	4,170	124.7	17.5	520,000	9,100,000	Sand	Timber	44,000	765,000
L. B ...	Just above Hickman............	....do	35.0	3,210	137.1	29.5	440,000	12,980,000	Sand and clay.	....do	37,000	1,091,000
L. B ...	Hickman Bend, at and below Hickman.	....do	39.2	11,490	36.6	19.6	420,000	8,232,000	Sand	0.9 cultivated..	35,000	692,000
R. B ...	Head of Island No. 7 and above.	....do	41.0	3,740	45.0	12.5	168,000	2,100,000	(?)	Timber	14,000	176,000
R. B ...	Bend opposite Island No. 8	....do	47.2	9,310	82.9	21.7	772,000	16,752,000	(?)	0.7 cultivated..	65,000	1,406,000
L. B ...	Head of Island No. 8............	....do	43.5	1,500	21.3	12.7	32,000	406,000	(?)	Timber	3,000	34,000
L. B ...	Lesters Landing and above......	....do	52.4	4,920	37.4	14.5	184,000	2,668,000	Sand and clay.	0.1 cultivated..	15,000	224,000
R. B ...	Donaldson Point................	....do	56.4	2,140	33.6	14.6	72,000	1,051,000	....do	0.5 cultivated..	6,000	88,000
L. B ..	Bend opposite Island No. 10	....do	61.2	7,280	224.4	24.7	1,634,000	40,360,000	Sand	Cultivated	137,000	3,387,000
L. B ...	Watsons Point	....do	67.8	3,490	70.0	14.0	244,000	3,416,000	....do	Timber	21,000	287,000
R. B ...	New Madrid Bend	Jan., 1880–Nov., 1891	72.0	10,120	149.8	22.8	1,516,000	4,565,000	Sand and clay.	Cultivated	128,000	2,929,000
L. B ...	Harris Landing.................	....do	75.8	5,140	244.7	20.1	1,258,000	25,286,000	Sand	....do	107,000	2,143,000
R. B ...	Point Pleasant and above.......	....do	78.5	5,350	127.5	10.4	682,000	7,093,000	....do	0.2 cultivated..	58,000	601,000
L. B ...	Darnells Point....	....do	79.6	5,050	831.7	14.4	4,200,300	60,480,000	....do	0.5 cultivated..	356,000	5,125,000
R. B ...	Lazelles Landing above Ruddles Point.	....do	83.0	5,860	299.7	23.8	1,756,000	41,793,000	....do	Cultivated	149,000	3,542,000
L. B ...	Merriwether Bend, Tiptonville .	....do	86.0	11,730	228.0	18.0	2,674,000	48,132,000	....do	0.2 cultivated..	227,000	4,079,000
R. B ...	Little Cypress Bend	....do	93.0	9,840	276.8	24.1	2,724,000	65,648,000	(?)	0.1 cultivated..	231,000	5,563,000
L. B ...	Bend at Reelfoot Landing	Jan., 1880–Dec., 1891	98.8	17,590	95.2	18.5	1,674,000	30,969,000	Sand and clay.	0.2 cultivated..	141,000	2,602,000
R. B ...	Gayoso	....do	106.4	7,020	246.2	26.2	1,728,000	45,274,000	Sand	0.9 cultivated..	145,000	3,835,000
R. B ...	Caruthersville.................	....do	110.7	5,350	107.7	17.4	576,000	10,022,000	Sand and clay.	....do	48,000	842,000
L. B ...	Opposite Islands 16 and 17......	....do	116.3	7,700	18.5	17.7	142,000	2,513,000	....do	Timber	12,000	211,000
R. B ...	Island No. 18	....do	120.4	4,490	220.0	11.3	988,000	11,164,000	Sand	....do	83,000	938,000
R. B ...	Opposite Island No. 20..........	....do	126.0	12,050	154.5	19.7	1,862,000	36,681,000	Sand and clay.	0.3 cultivated..	156,000	3,080,000
L. B ...	Island No. 21	Feb., 1880–Dec., 1891	129.5	2,350	29.0	15.5	68,000	1,054,000	(?)	Timber	6,000	89,000
R. B ...	Just below Hickman's Landing.	....do	131.8	1,500	50.7	22.0	76,000	1,672,000	Sand and clay.	Cultivated	6,000	143,000
L. B ...	Bend below mouth of Obion River.	....do	137.0	9,200	197.4	23.2	1,816,000	42,131,000	....do	0.3 cultivated..	154,000	3,570,000

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R. B	Bend opposite Ruckers Point	...do	142.6	9,120	275.2	22.4	2,510,000	56,224,000	...do	...do	213,000	4,765,000
L. B	Bend above Forked Deer Island	...do	146.0	4,960	177.4	18.5	880,000	16,280,000	...do	Timber	75,000	1,380,000
L. B	Forked Deer Island	...do	148.3	6,850	289.1	16.5	1,980,000	32,670,000	Sand	...do	168,000	2,769,000
R. B	Daniells Point and above	...do	151.3	5,780	240.5	19.2	1,390,000	26,688,000	Sand and clay	...do	118,000	2,262,000
L. B	Bend opposite Ashport Bar	...do	154.8	6,630	181.9	19.7	1,206,000	23,758,000	...do	0.2 cultivated	102,000	2,013,000
R. B	Elmot Landing and above	...do	160.0	3,970	185.4	16.2	736,000	11,923,000	Sand	Timber	62,000	1,010,000
R. B	Osceola Bar and bars above	...do	164.0	5,990	137.9	12.5	826,000	10,325,000	(?)		70,000	875,000
R. B	Upper side of Craighead Point	...do	169.0	4,710	187.3	19.7	882,000	17,375,000	Sand and clay	0.1 cultivated	75,000	1,472,000
L. B	Hatchee Landing	...do	173.7	1,500	25.4	19.3	38,000	733,000	Sand and gravel.	Timber	3,000	62,000
R. B	Falls Landing	...do	175.7	1,610	22.4	15.7	36,000	565,000	(?)	Cultivated	3,000	48,000
R. B	Island No. 34	...do	176.5	4,490	328.7	13.7	1,476,000	20,221,000	(?)	0.5 cultivated	125,000	1,714,000
R. B	Morgans Point	...do	182.5	5,350	247.8	17.7	1,326,000	23,470,000	(?)	Cultivated	112,000	1,989,000
L. B	Fort Wright	...do	184.8	3,380	49.7	24.0	168,000	4,032,000	(?)	...do	14,000	342,000
R. B	Chute of Island No. 35	...do	189.0	4,090	165.8	10.7	678,000	7,255,000	Sand	...do	57,000	615,000
R. B	Bend opposite Island No. 35	...do	191.4	19,260	177.6	19.8	3,420,000	67,716,000	Sand and clay	0.8 cultivated	290,000	5,739,000
L. B	Chute of Island No. 35	...do	195.0	6,000	185.3	13.7	556,000	7,617,000	...do	...do	47,000	646,000
R. B	Deans Island	...do	198.0	4,280	127.6	16.3	546,000	8,900,000	(?)	...do	46,000	754,000
L. B	Centennial cut-off and above	...do	201.5	10,120	268.0	16.2	2,712,000	43,934,000	Sand and clay	0.5 cultivated	230,000	3,723,000
R. B	Centennial Island	Mar., 1880–Dec., 1891	205.0	5,290	279.8	20.8	1,480,000	30,784,000	...do	0.2 cultivated	125,000	2,609,000
R. B	Fogelman Chute	...do	208.8	5,140	98.0	21.3	504,000	10,735,000	(?)	Timber	43,000	910,000
L. B	Randolph Point	...do	211.5	3,100	231.0	24.0	716,000	17,184,000	(?)	Cultivated	61,000	1,456,000
R. B	Bar opposite head of Beef Island	...do	213.5	4,070	312.5	4.5	1,272,000	5,724,000	Sand	Bar	108,000	485,000
	Head of Beef Island	...do	213.0	7,920	186.6	13.3	1,478,000	19,657,000	...do	0.8 cultivated	125,000	1,666,000
L. B	In chute of Beef Island	...do	213.0	3,210	201.2	11.9	646,000	7,687,000	(?)	0.5 cultivated	55,000	652,000
	R. B. of Beef Island Chute	...do	215.0	2,250	119.1	12.3	268,000	3,296,000	(?)	...do	23,000	278,000
R. B	Bend opposite Beef Island	...do	218.2	5,560	97.8	20.6	544,000	11,206,000	Sand	Timber	38,000	950,000
R. B	Harrisons Landing	...do	221.0	680	23.5	15.0	16,000	240,000	Clay	Cultivated	1,000	20,000
L. B	Old Hen Island and above	...do	225.0	11,660	321.1	17.2	3,744,000	64,397,000	Sand	0.5 cultivated	318,000	5,456,000
R. B	Lower part of Hopefield Bend	Oct., 1877–Dec., 1891	229.0	8,900	576.2	22.1	5,128,000	113,329,000	Sand and clay	Timber	361,000	7,981,000
L. B	Tennessee Chute and above	...do	235.0	11,980	139.6	15.6	1,672,000	26,083,000	...do	0.7 cultivated	118,000	1,837,000
	Tennessee Chute, head Presidents Island.	...do	234.5	4,750	258.5	13.5	1,228,000	16,578,000	...do	0.1 cultivated	86,000	1,167,000
	Tennessee Chute, foot Presidents Island.	...do	238.0	2,140	82.4	13.3	176,000	2,341,000	(?)	Timber	12,000	165,000
R. B	Reeves Landing	Dec., 1877–Dec., 1891	243.0	7,020	139.5	15.0	980,000	14,700,000	Clay	Cultivated	70,000	1,050,000
L. B	Horn Lake Landing	...do	244.5	7,960	329.9	15.7	2,626,000	41,228,000	Sand and clay	0.7 cultivated	188,000	2,945,000
R. B	Cow Island Bend	Nov., 1878–Dec., 1891	250.6	11,660	345.1	19.8	4,024,000	79,675,000	Clay	0.2 cultivated	307,000	6,082,000
L. B	Opposite Cat Island	...do	257.0	11,560	294.3	15.6	3,402,000	53,071,000	Sand and clay	0.8 cultivated	259,000	4,050,000
L. B	Opposite Woodstock Landing	...do	261.0	2,890	78.9	6.0	228,000	1,368,000	Sand	0.9 cultivated	17,000	104,000
R. B	Woodstock Landing	...do	262.0	6,310	220.9	11.9	1,394,000	16,589,000	Sand and clay	0.3 cultivated	106,000	1,266,000
L. B	Polks Landing and below	...do	267.0	7,360	570.7	10.2	4,200,000	42,840,000	Sand	Timber	321,000	3,270,000
R. B	Blues Point	Dec., 1878–Jan., 1892	269.0	3,850	83.6	11.0	322,000	3,542,000	...do	Bar	25,000	270,000
R. B	Ashley Point	Dec., 1880–Jan., 1892	274.5	9,420	242.0	11.1	2,280,000	25,308,000	...do	0.5 cultivated	205,000	2,280,000
L. B	Bordeaux Chute and above	...do	278.2	6,630	470.0	20.0	3,116,000	62,320,000	Sand and clay	0.1 cultivated	281,000	5,614,000
R. B	Foot of Bordeaux Island	...do	280.5	1,710	649.1	17.8	1,110,000	19,758,000	Sand	Timber	100,000	1,780,000
R. B	Walnut Bend Landing and above.	...do	281.5	5,160	469.8	18.0	2,424,000	43,632,000	Sand and clay	0.8 cultivated	218,000	3,931,000
L. B	Below Walnut Bend Landing	Feb., 1881–Jan., 1892	284.5	6,030	419.6	12.3	2,530,000	31,119,000	Sand	Bar	232,000	2,855,000
R. B	Upper side of Hardins Point	...do	285.8	1,600	76.3	24.3	122,000	2,965,000	...do	Timber	11,000	272,000
L. B	Harberts Landing	...do	291.4	6,030	260.0	20.3	1,568,000	31,830,000	Sand and clay	0.2 cultivated	144,000	2,920,000
R. B	St. Francis Bend	...do	295.5	8,600	147.9	18.2	1,272,000	23,150,000	Sand	Timber	117,000	2,124,000

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Right or left bank	Locality.	Dates of surveys.	Distance from Cairo.	Length.	Average width.	Average depth.	Total area of caving.	Total volume of caving.	Character of bank.		Caving per annum.	
									Soil.	Vegetation.	Area.	Volume.
			Miles.	*Yards.*	*Yards.*	*Yards.*	*Sq. yards.*	*Cubic yards.*			*Sq. y'ds.*	*Cu. yards.*
L. B ...	Trotters Landing	Feb., 1881–Jan., 1892	304.0	5,780	302.8	23.4	1,750,000	40,956,000	Sand and clay	0.8 cultivated	161,000	3,757,000
R. B ...	Just below Helena	...do	309.0	8,770	87.3	21.8	766,000	16,699,000	Sand	Cultivated	70,000	1,532,000
L. B ...	Delta Landing	...do	315.0	3,850	89.9	25.3	346,000	8,754,000	(?)	...do	32,000	803,000
L. B ...	Friars Point Landing	...do	318.5	2,460	61.8	13.0	152,000	1,976,000	(?)	...do	14,000	181,000
L. B ...	Bar below Friars Point	...do	319.5	640	62.5	5.3	40,000	212,000	Sand	...do	4,000	19,000
R. B ...	Westover Landing	Mar., 1881–Jan., 1892	319.0	3,850	67.0	20.7	258,000	5,341,000	Sand and clay	...do	24,000	494,000
L. B ...	Millers Point	...do	322.7	5,140	444.4	23.0	2,284,000	52,532,000	...do	0.2 cultivated	211,000	4,864,000
R. B ...	Old Town Bend	...do	327.0	8,020	106.7	22.2	856,000	19,003,000	...do	Timber	79,000	1,760,000
L. B ...	Opposite T. H. of Island No. 62	...do	331.0	3,550	89.0	22.4	316,000	7,078,000	...do	...do	29,000	655,000
L. B ...	Island No. 63	...do	332.0	4,490	181.3	21.5	814,000	17,501,000	Sand	...do	75,000	1,620,000
R. B ...	Hugheys Landing	...do	336.5	8,800	130.9	15.7	1,152,000	18,086,000	Sand	0.2 cultivated	108,000	1,650,000
L. B ...	Opposite Island No. 64	...do	341.0	8,350	323.8	20.3	2,704,000	54,891,000	...do	0.3 cultivated	252,000	5,036,000
R. B ...	Opposite Jacksons Point	...do	344.0	4,920	149.2	26.7	734,000	19,598,000	...do	Timber	72,000	1,798,000
R. B ...	Bend above St. Louis Landing, head of Island No. 66.	...do	348.5	9,720	96.7	23.1	940,000	21,714,000	Sand and clay	0.2 cultivated	88,000	1,992,000
L. B ...	Bend opposite Island No. 66	Oct., 1881–Jan., 1892	353.0	11,430	174.7	23.9	1,996,000	47,704,000	...do	Timber	194,000	4,631,000
L. B ...	Pushmataha Landing	...do	359.0	5,350	41.1	18.6	220,000	4,092,000	Sand	0.3 cultivated	21,000	397,000
R. B ...	Below Ludlows Landing	...do	360.3	730	16.6	14.0	12,000	168,000	(?)	Timber	1,000	16,000
	Island No. 68	...do	362.3	3,750	195.7	11.3	734,000	8,294,000	Sand and clay	...do	71,000	805,000
R. B ...	Opposite Island No. 68	...do	362.5	4,120	114.1	26.4	470,000	12,408,000	...do	...do	46,000	1,204,000
R. B ...	Head of Island No. 69 and above	Nov., 1881–Jan., 1892	367.5	4,280	89.2	20.9	372,000	7,775,000	...do	...do	36,000	762,000
L. B ...	Bend opposite Island No. 69	...do	370.8	13,700	201.8	23.1	2,764,000	63,848,000	...do	0.2 cultivated	268,000	6,260,000
R. B ...	Head of Islands Nos. 70 and 71 and above.	...do	376.0	6,420	325.9	26.8	2,092,000	56,066,000	Sand	Timber	205,000	5,496,000
L. B ...	Bend opposite Island No. 71	...do	380.0	6,850	311.2	28.6	2,132,000	60,975,000	Sand and clay	...do	209,000	5,978,000
R. B ...	Foot of Island No. 71	...do	381.5	1,600	55.0	9.3	88,000	818,000	Sand	...do	8,000	80,000
L. B ...	Smiths Point and above	...do	382.7	4,070	266.8	19.0	1,086,000	20,634,000	...do	0.5 cultivated	106,000	2,023,000
R. B ...	Scrub Grass Bend	Nov., 1881–Feb., 1892	386.5	1,040	137.5	25.7	1,518,000	39,013,000	Sand and clay	Timber	146,000	3,787,000
R. B ...	Above and below Montgomery Cut-off.	...do	391.5	4,070	45.2	10.7	184,000	1,969,000	Sand	...do	18,000	191,000
L. B ...	Opposite and above mouth of White River.	...do	392.0	8,820	135.8	24.8	1,198,000	29,610,000	Sand and clay	0.3 cultivated	116,000	2,874,000
R. B ...	Malones Landing and above	Dec., 1881–Feb., 1892	396.5	6,060	147.2	26.1	892,000	23,281,000	...do	Timber	87,000	2,282,000
L. B ...	Wrights Point and above	...do	399.5	5,630	377.4	25.0	2,120,000	53,150,000	...do	0.3 cultivated	208,000	5,211,000
R. B ...	Below mouth of Arkansas River	...do	403.5	6,630	140.3	13.6	930,000	12,648,000	Sand	Timber	91,000	1,240,000
L. B ...	Wildwood Point and above	...do	406.0	7,060	301.7	23.5	2,130,000	50,055,000	...do	...do	207,000	4,907,000
R. B ...	Bend below Ozark Island	...do	409.3	4,960	246.4	32.7	1,222,000	39,959,000	Sand and clay	...do	120,000	3,907,000
L. B ...	Opposite Holly Ridge Landing	...do	411.8	2,670	167.0	11.7	446,000	5,218,000	Sand	...do	44,000	511,000
R. B ...	Caulks Landing	...do	413.8	6,420	143.6	13.5	922,000	12,447,000	Sand and clay	0.5 cultivated	90,000	1,220,000
L. B ...	Head and foot of Island No. 76	...do	416.0	4,280	269.6	18.0	1,154,000	20,772,000	Sand	Timber	113,000	2,036,000
R. B ...	Opposite Kentucky Landing	...do	418.8	1,370	43.8	17.4	60,000	1,044,000	(?)	...do	6,000	102,000
L. B ...	Bolivar Landing and below	...do	418.2	7,700	192.7	31.7	1,484,000	47,043,000	Sand	0.5 cultivated	145,000	4,612,000

L. B ...	Catfish Point	Jan., 1882–Feb., 1892	422.3	5,460	165.9	19.8	906,000	17,939,000	Sand and clay	1.0 cultivated	90,000	1,776,000
R. B ...	Bend opposite Catfish Point	...do	427.7	17,850	146.9	30.8	2,622,000	80,758,000	...do	0.5 cultivated	260,000	7,995,000
L. B ...	Choctaw Bend	...do	436.0	12,070	148.3	22.8	1,790,000	4,081,000	...do	1.0 cultivated	175,000	404,000
R. B ...	Bend below Arkansas City	...do	441.5	9,690	139.1	29.4	1,348,000	89,631,000	S'd, cl., gravel	Timber	133,000	3,924,000
L. B ...	Georgetown Bend	Oct., 1882–Feb., 1892	447.0	11,340	276.9	24.9	3,150,000	79,435,000	(?)	...do	338,000	8,541,000
R. B ...	Bend opposite Ashbrook Point	...do	452.0	10,800	243.5	29.7	2,630,000	78,111,000	Sand	...do	283,000	8,398,000
L. B ...	Millers Bend and below	...do	460.5	17,980	143.9	26.3	2,588,000	68,064,000	Sand and clay	...do	280,000	7,318,000
R. B ...	Spanish Moss Bend and below	...do	469.0	20,440	202.9	25.0	4,148,000	103,700,000	...do	0.8 cultivated	446,000	11,150,000
L. B ...	Greenville	Oct., 1881–Feb., 1892	477.5	13,800	339.6	26.2	4,686,000	122,773,000	...do	0.3 cultivated	455,000	11,919,000
R. B ...	Walkers Bend	Nov., 1881–Feb., 1892	487.5	14,770	148.5	20.4	2,194,000	42,718,000	...do	0.1 cultivated	215,000	4,188,000
L. B ...	Walnut Point	...do	494.3	8,670	242.2	20.1	2,100,000	42,210,000	Sand	Timber	206,000	4,138,000
R. B ...	American Cut-off	Dec., 1881–Feb., 1892	497.4	4,020	191.5	23.0	770,000	17,710,000	...do	...do	75,000	1,736,000
L. B ...	Above Fanny Bullitts T. H	...do	500.0	6,200	507.1	26.8	3,144,000	84,259,000	Sand and clay	0.6 cultivated	308,000	8,261,000
L. B ...	Fanny Bullits T. H	...do	502.7	3,210	254.2	15.0	816,000	12,240,000	Sand	Timber	80,000	1,200,000
R. B ...	Opposite Fanny Bullits T. H	...do	503.8	3,890	219.5	23.1	854,000	19,727,000	...do	...do	84,000	1,934,000
R. B ...	Grand Lake Landing (Mathews Bend).	...do	509.5	9,200	267.6	28.6	2,462,000	70,413,000	Sand and clay	0.5 cultivated	241,000	6,903,000
L. B ...	Leota Landing	...do	513.3	8,350	807.2	25.6	6,740,000	72,544,000	Sand	0.5 cultivated	660,000	16,916,000
R. B ...	Island and above (No. 89)	...do	515.5	5,890	369.4	20.3	2,176,000	44,156,000	...do	0.6 cultivated	213,000	4,329,000
L. B ...	Sarahs Island	Jan., 1882–Feb., 1892	519.5	5,990	906.8	28.0	5,432,000	52,096,000	(?)	0.2 cultivated	532,000	15,054,000
R. B ...	Louisana Bend and below	...do	524.5	11,020	588.9	30.9	6,490,000	60,541,000	(?)	0.1 cultivated	636,000	19,856,000
L. B ...	Bunches Cut-off	Dec., 1881–Feb., 1892	528.5	6,030	371	10.7	2,238,000	23,947,000	(?)	0.3 cultivated	219,000	2,348,000
R. B ...	Below Bunches Landing	...do	530.0	6,100	567	16.4	346,000	2,560,000	(?)	1.0 cultivated	34,000	251,000
L. B ...	Mayersville Landing	Sept., 1882–Feb., 1892	533.4	10,490	88	9.9	924,000	9,148,000	(?)	0.5 cultivated	98,000	963,000
R. B ...	Lake Providence (above and below).	...do	541.8	16,780	314	21.4	5,276,000	112,906,000	Sand and clay	1.0 cultivated	560,000	11,990,000
L. B ...	Ben Lomond Landing and below	Oct., 1882–Feb., 1892	543.2	4,920	775	17.1	3,812,000	65,185,000	Sand	1.0 cultivated	409,000	6,987,000
R. B ...	Opposite and below Ajax Bar	...do	547.8	6,550	131	25.1	856,000	21,486,000	Sand and clay	Timber	92,000	2,303,000
L. B ...	Island No. 95	...do	551.7	2,780	913	21.6	2,538,000	54,821,000	Sand	0.6 cultivated	272,000	5,884,000
L. B ...	Fitlers Point and below	...do	553.2	6,630	581	28.9	3,918,000	113,230,000	...do	1.0 cultivated	420,000	12,136,000
R. B ...	Above Island No. 97	...do	555.5	7,700	419	9.7	3,228,000	31,312,000	...do	Timber	346,000	3,356,000
	Island No. 97	...do	558.5	3,100	395	19.8	1,224,000	24,235,000	...do	...do	131,000	2,596,000
L. B ...	Opposite Island No. 97	...do	558.5	7,700	184	21.1	1,416,000	29,878,000	...do	1.0 cultivated	152,000	3,202,000
R. B ...	Willow Point and above	...do	565.2	10,190	837	23.1	8,532,000	197,089,000	...do	1.0 cultivated	914,000	21,124,000
L. B ...	Island No. 98, above and below	Nov., 1882–Feb., 1892	570.4	17,120	652	20.7	11,156,000	230,929,000	Sand and clay	0.8 cultivated	1206,000	24,976,000
R. B ...	Terrapin Neck Cut-off	...do	576.0	6,850	524	29.7	3,590,000	106,623,000	...do	0.2 cultivated	386,000	11,527,000
	Island No. 102	...do	577.7	1,710	416	25.7	712,000	18,295,000	Sand	Timber	77,000	1,978,000
R. B ...	Millikens Bend	...do	582.3	15,190	352	22.1	5,346,000	118,147,000	(?)	1.0 cultivated	578,000	12,773,000
L. B ...	Head of Paw Paw Island and above.	Jan., 1881–Feb., 1892	585.7	12,070	409	17.7	4,940,000	87,438,000	Sand and clay	Timber	446,000	7,889,000
R. B ...	Opposite Paw Paw Island	...do	589.7	4,940	272	25.0	1,346,000	33,650,000	...do	Cultivated	121,000	3,036,000
L. B ...	Above mouth of Yazoo River	...do	592.1	5,140	281	20.2	1,448,000	29,250,000	Sand	Timber	131,000	2,639,000
R. B ...	Opposite mouth of Yazoo River	...do	594.5	5,520	303	29.0	1,670,000	48,430,000	Sand and clay	0.6 cultivated	151,000	4,360,000
L. B ...	Kings Point and below	...do	597.6	4,070	172	12.0	700,000	8,400,000	Sand	1.0 cultivated	63,000	758,000
R. B ...	Delta	...do	598.1	3,850	96	26.7	370,000	9,879,000	Sand and clay	1.0 cultivated	33,000	890,000
L. B ...	Kleinston and below	...do	601.5	4,840	424	30.3	2,050,000	62,115,000	...do	0.7 cultivated	185,000	5,605,000
R. B ...	Bedford Landing and above	Dec., 1881–Feb., 1892	604.8	10,230	714	26.8	7,300,000	195,640,000	Sand	0.7 cultivated	718,000	19,140,000
L. B ...	Oak Bend Landing	Nov., 1882–Feb., 1892	610.0	12,280	486	21.8	5,974,000	130,233,000	Sand and clay	0.7 cultivated	646,000	14,079,000
R. B ...	Foot of Diamond Island T. H. and below	...do	615.0	10,910	625	20.8	6,814,000	141,731,000	...do	0.3 cultivated	737,000	15,322,000
L. B ...	Newton Bend	...do	620.2	12,200	683	21.7	8,336,000	180,891,000	...do	0.5 cultivated	901,000	19,437,000
R. B ...	Point Pleasant and below	...do	624.3	8,240	614	26.4	5,062,000	133,637,000	...do	0.4 cultivated	547,000	14,448,000

Table of caving banks between Cairo and Donaldsonville—Continued.

Right or left bank.	Locality.	Dates of surveys.	Distance from Cairo.	Length	Average width.	Average depth.	Total area of caving.	Total volume of caving.	Character of bank.		Caving per annum.	
									Soil.	Vegetation.	Area.	Volume.
			Miles.	*Yards.*	*Yards.*	*Yards.*	*Sq. yards.*	*Cubic yards.*			*Sq. yd's.*	*Cu. yards.*
L. B	Thrashers Point and above	Dec., 1882–Feb., 1892	628.3	5,990	638	29.2	3,820,000	111,544,000	Sand	Timber	416,000	12,124,000
R. B	Hard Times Bend	...do	632.2	11,860	362	25.1	4,290,000	107,679,000	...do	0.1 cultivated	463,000	11,704,000
L. B	Grand Gulf Island and below	...do	637.0	8,650	582	22.4	5,034,000	112,762,000	...do	0.1 cultivated	547,000	12,256,000
R. B	Hard Scrabble Landing	...do	641.6	11,130	501	27.8	5,572,000	164,802,000	...do	0.5 cultivated	606,000	17,913,000
L. B	Opposite St. Joseph	...do	647.3	13,700	198	20.5	2,718,000	55,719,000	...do	0.7 cultivated	295,000	6,056,000
R. B	St. Joseph and below	...do	650.5	9,720	379	31.7	3,686,000	116,826,000	...do	0.3 cultivated	401,000	12,698,000
L. B	Opposite Rodney Island	Jan., 1883–Feb., 1892	653.6	5,780	205	38.0	1,184,000	44,992,000	...do	0.5 cultivated	130,000	4,944,000
R. B	Below Rodney Island	...do	658.0	10,060	546	24.4	5,496,000	134,102,000	...do	0.8 cultivated	604,000	14,738,000
L. B	Beuna Vista Landing	...do	661.0	4,150	67	19.6	280,000	5,488,000	...do	0.6 cultivated	31,000	603,000
L. B	Coles Island	...do	664.0	1,390	391	17.0	544,000	9,248,000		Timber	60,000	1,016,000
	Coles Point Cut-off	...do	665.4	1,930	1,939	24.7	3,738,000	82,329,000	Sand and clay	1.0 cultivated	411,000	9,047,000
L. B	Fairchilds Island	...do	681.3	5,780	254	10.7	1,470,000	15,729,000	Sand	0.3 cultivated	162,000	1,728,000
R. B	Fairchilds Bend	Feb., 1883–Mar., 1892	683.0	10,560	153	31.5	1,620,000	51,030,000	...do	0.1 cultivated	178,000	5,607,000
L. B	Giles Bend	...do	688.5	9,970	344	31.5	3,428,000	107,982,000	Sand and clay	0.4 cultivated	377,000	11,866,000
R. B	Marengo Bend	...do	693.0	9,120	850	33.8	7,840,000	264,992,000	Sand	0.7 cultivated	862,000	29,120,000
R. B	Opposite Giles Landing	...do	697.2	1,930	340	32.3	656,000	11,189,000	...do	0.8 cultivated	72,000	1,229,000
R. B	Above Vidalia	...do	700.0	1,160	41	14.6	48,000	701,000	(?)	Timber	5,000	77,000
L. B	Natchez	Nov., 1882–Mar., 1892	700.3	4,920	33	27.3	160,000	4,368,000	Clay	1.0 cultivated	17,000	480,000
L. B	Opposite White Hall Landing	...do	703.8	1,500	29	17.3	44,000	761,000	(?)	1.0 cultivated	5,000	84,000
R. B	Natchez Island and below	...do	707.4	7,770	165	18.8	1,284,000	24,139,000	Sand	0.6 cultivated	141,000	2,653,000
R. B	Below Vidalia	...do	702.2	2,200	38	20.0	84,000	1,680,000	Sand and clay	1.0 cultivated	9,000	185,000
L. B	At St. Catharines Bend	...do	711.8	9,650	850	14.4	4,374,000	48,586,000	Sand	Timber	363,000	5,224,000
R. B	Esperance Point	...do	714.8	4,880	642	24.8	3,134,000	77,723,000	Sand and clay	0.3 cultivated	337,000	8,357,000
L. B	Ellis Cliffs and below	...do	718.3	10,490	365	30.3	3,824,000	115,867,000	...do	0.3 cultivated	411,000	12,458,000
R. B	Opposite Glasscock T. H	Dec., 1882–Mar., 1892	722.0	6,680	704	21.8	4,704,000	102,547,000	Sand	0.7 cultivated	511,000	11,086,000
L. B	Glasscock Island	...do	724.6	4,240	214	14.3	892,000	12,756,000	...do	Timber	97,000	1,379,000
R. B	Above Dead Mans Bend	...do	726.2	4,960	218	36.2	1,080,000	39,096,000	...do	0.6 cultivated	117,000	4,227,000
L. B	Dead Mans Bend	...do	732.7	18,450	88	27.1	1,620,000	43,902,000	Sand and clay	1.0 cultivated	176,000	4,746,000
R. B	Union Point and above	...do	740.0	10,020	216	36.3	2,166,000	78,626,000	Sand	0.3 cultivated	235,000	8,500,000
L. B	Two miles above Kienstras Landing.	...do	740.8	1,500	157	15.0	236,000	3,540,000	...do	Timber	26,000	382,000
L. B	Palmetto Point	...do	745.8	10,120	249	26.9	2,516,000	67,680,000	...do	0.3 cultivated	273,000	7,316,000
R. B	Black Hawk Point Landing	...do	749.6	5,220	195	31.4	1,016,000	31,902,000	(?)	0.2 cultivated	110,000	3,449,000
L. B	Bartlet's wood yard	Jan., 1883–Mar., 1892	752.0	3,770	105	28.9	394,000	11,387,000	(?)	Timber	43,000	1,231,000
R. B	Above Knox Landing	...do	752.5	1,030	35	7.3	36,000	263,000	(?)	...do	4,000	29,000
R. B	Point Breeze	...do	754.6	2,350	276	40.9	650,000	26,595,000	(?)	0.1 cultivated	71,000	2,891,000
L. B	Below Fort Adams	...do	756.8	4,540	279	44.0	1,270,000	55,880,000	(?)	1.0 cultivated	138,000	6,074,000
L. B	At State line	...do	761.3	3,470	70	8.0	244,000	1,952,000	Sand	1.0 cultivated	26,000	212,000
R. B	Above mouth of Red River	...do	761.5	8,240	25	26.0	202,000	5,252,000	(?)	Timber	22,000	571,000
R. B	Below mouth of Red River	...do	764.4	1,070	62	10.6	66,000	700,000	(?)	...do	7,000	76,000
L. B	Racourci Cut-off	...do	767.6	4,490	41	6.3	186,000	1,172,000	(?)	...do	20,000	127,000
R. B	...do	...do	768.6	13,100	42	32.2	546,000	17,581,000	Sand and clay	0.2 cultivated	59,000	1,911,000

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L. B ...	Tunica Bend	...do	777.0	5,780	82	26.6	472,000	12,555,000	...do	0.7 cultivated	51,000	1,365,000
	Tunica Island	...do	779.0	2,400	30	18.3	72,000	1,318,000	(?)	Timber	8,000	148,000
R. B ...	Above Brunette Point	Feb., 1883–Mar., 1892	780.4	4,710	66	24.9	312,000	7,769,000	(?)	...do	34,000	854,000
L. B ...	Iowa Point and above	...do	783.5	3,980	130	36.4	518,000	18,855,000	Sand and clay	...do	56,000	2,072,000
R. B ...	Morganza Crevasse (above and below.)	...do	788.2	13,380	59	42.8	788,000	33,736,000	...do	0.7 cultivated	87,000	3,706,000
L. B ...	Opposite Blue Store	...do	793.6	5,480	74	37.8	406,000	15,347,000	(?)	Timber	44,000	1,686,000
R. B ...	Above Point Coupeé	...do	796.6	11,130	34	30.0	374,000	11,220,000	Sand and clay	0.9 cultivated	41,000	1,233,000
L. B ...	Below Bayou Sara	Jan., 1883–Mar., 1892	802.3	8,130	25	35.2	202,000	7,110,000	...do	Timber	22,000	774,000
L. B ...	Fancy Point	...do	807.3	2,570	40	12.0	104,000	1,248,000	Sand	...do	11,000	136,000
R. B ...	Hermitage Landing	...do	807.8	6,160	138	33.8	852,000	28,798,000	...do	...do	92,000	3,130,000
L. B ...	Below Port Hickey	...do	811.0	2,700	48	53.0	130,000	6,890,000	Sand and clay	...do	14,000	749,000
R. B ...	Opposite Profit Island	...do	815.3	9,820	91	32.0	938,000	30,016,000	...do	0.8 cultivated	102,000	3,263,000
L. B ...	Springfield Bend	...do	820.6	6,930	191	34.4	1,320,000	45,408,000	Sand	Timber	144,000	4,936,000
R. B ...	Opposite Thomas Point	Feb., 1883–Mar., 1892	824.0	4,820	87	40.1	416,000	16,682,000	Sand and clay	Cultivated	46,000	1,813,000
R. B ...	Point Place Landing	...do	828.3	1,880	26	35.0	50,000	1,750,000	(?)	...do	5,000	192,000
R. B ...	Above Anchorage Landing	...do	830.5	2,780	16	17.0	44,000	7,748,000	Clay	...do	5,000	82,000
R. B ...	Sunny Side Landing to below Union Store Landing	...do	834.0	8,820	25	23.2	218,000	5,058,000	(?)	...do	24,000	555,000
L. B ...	Below Baton Rouge	...do	836.0	7,810	23	36.0	176,000	6,336,000	Sand and clay	...do	19,000	696,000
R. B ...	Missouri Landing	...do	839.6	430	47	30.7	20,000	614,000	(?)	...do	2,000	67,000
R. B ...	Opposite Duncans Point	...do	841.2	5,560	43	29.9	240,000	7,176,000	Sand	...do	26,000	788,000
L. B ...	Duncans Point	...do	840.4	750	27	12.3	20,000	246,000	...do	...do	2,000	27,000
L. B ...	Hollywood Landing	...do	841.7	5,890	45	17.1	266,000	4,549,000	Clay	...do	29,000	500,000
R. B ...	Upper side of Manchac Point	...do	843.2	2,140	21	20.7	44,000	911,000	...do	...do	5,000	100,000
L. B ...	Manchac Landing to opposite Ridgefield Landing.	...do	849.8	9,840	15	24.3	148,000	3,596,000	Sand and clay	...do	16,000	395,000
R. B ...	Lower side Manchac Point to Arcadia Landing.	...do	853.5	19,260	40	28.0	774,000	21,672,000	...do	...do	85,000	2,381,000
L. B ...	Opposite St. Louis Landing	Mar., 1883–Mar., 1892	855.0	2,740	47	10.6	130,000	1,378,000	(?)	...do	14,000	153,000
L. B ...	Magnolia Landing	...do	859.5	5,030	25	25.0	124,000	3,100,000	(?)	...do	14,000	344,000
L. B ...	Opposite Point Pleasant	...do	863.2	6,530	19	33.8	124,000	4,191,000	(?)	...do	14,000	466,000
R. B ...	Bend opposite Point Clair	...do	868.3	13,740	44	34.3	610,000	20,923,000	(?)	...do	68,000	2,315,000
L. B ...	Bend opposite Claiborne Island	...do	874.6	9,420	45	32.9	426,000	14,015,000	(?)	...do	47,000	1,557,000
R. B ...	Philadelphia Point	...do	878.8	3,000	46	23.0	138,000	3,174,000	(?)	...do	15,000	353,000
L. B ...	81 Mile Point	...do	881.0	4,580	50	34.4	230,000	7,912,000	(?)	...do	26,000	879,000
R. B ...	Bend opposite 81 Mile Point	...do	883.2	5,560	14	31.8	79,000	2,512,000	(?)	...do	9,000	279,000

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APPENDIX 4 H.

TABULATED RESULTS, WITH FIELD AND OFFICE REPORTS, OF DISCHARGE MEASUREMENTS ON THE MISSISSIPPI, OHIO, AND ATCHAFALAYA RIVERS, AND OF CREVASSE AND OVERFLOW MEASUREMENTS, 1891.

Contents.

EXTRACTS FROM REPORT OF MR. C. W. STURTEVANT, ASSISTANT ENGINEER, CHIEF OF PARTY, UPON HIGH-WATER DISCHARGE OBSERVATIONS, MISSISSIPPI RIVER, AT COLUMBUS, FULTON, AND MEMPHIS, 1891.

STEAMER H. L. ABBOT,
Memphis, Tenn., April 21, 1891.

I have the honor to submit the following report upon the discharge observations taken at Memphis, Tenn., Columbus, Ky., and Fulton, Tenn., during the high water of 1891.

At Memphis the same sections and signals were used that were erected in March, 1890, for high-water discharges at this place. The observations were taken with Price meter No. 29 at $\frac{6}{10}$ depth.

* * * * * * *

At Columbus, Ky. [from March 11 to 25], and Fulton, Tenn., the observations for velocity were made with mid-depth floats in the following manner.

The tug would turn the skiff loose about 600 feet above the section. As soon as it became steady and had arrived within about 400 feet of the range the float was let loose and the skiff kept within 10 feet of it; when about 200 feet of the section a flag was waved and the position of the float at this instant was located by two transit angles from shore. In sixty seconds, or some other convenient time, the flag was again waved and the float located, after which the float was taken into the skiff and the skiff towed into position for the next float by the tug.

After the field work was performed the angles to floats were plotted on drawing paper, scale 300 feet to the inch, after which the path of the float was resolved into two components, one parallel to the section and one normal to the section. The length of this normal was scaled off and the distance divided by the number of seconds that the float ran, which gave the velocity in feet per second for that point in the section where the path, or path produced, intersects the section.

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The double float consisted of a mid-depth float and a surface float joined by a string whose length was such that the mid-depth float should sink halfway to the bottom of the river.

The mid-depth float was a box 3 by 1 by 1 foot, without ends, so weighted as to stand in a perpendicular position in the water and to sink the surface float down to a point midway between the apex and the base of the upper cone.

The surface float consisted of two hollow water-tight cones joined at their bases and carrying a flag 6 inches square and 18 inches above the surface of the water. The distance from apex to apex of the two cones was 12 inches and the diameter 6 inches.

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Check soundings at Columbus, Ky., were made with a 32¼-pound weight and piano wire. A rough wooden reel was constructed to draw the weight from the bottom. When the weight touched bottom it was very hard to catch the exact point on the wire, as it was so small it could not be checked in its downward motion at once. For this reason the results can be relied upon only for the nearest foot. Tags were tied to the wire between drops of solder.

At Fulton, Tenn., an iron reel was used to raise and lower the weight, which was 56¼ pounds in weight. No tags were placed on the wire, the number of turns of the reel being counted when drawing the weight off of the bottom. This method was very satisfactory indeed, and the results can be relied upon to the nearest quarter of a foot.

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Capt. S. W. Roessler,
Corps of Engineers, U. S. A., Memphis, Tenn.

EXTRACTS FROM REPORT OF MR. WILLIAM GERIG, ASSISTANT ENGINEER, CHIEF OF PARTY, UPON DISCHARGE OBSERVATIONS, MISSISSIPPI RIVER, AT MEMPHIS, HELENA, AND ROBERTSONVILLE CREVASSE, MARCH AND APRIL, 1891.

Memphis, Tenn., *May 6, 1891.*

* * * * * * *

I have the honor to submit the following report upon the discharge observations taken at Memphis, Tenn., March 10, Helena, Ark., and Robertsonville, Miss., crevasse during high water, 1891.

At Memphis the same section and signals were used that had been erected by Assistant C. W. Sturtevant.

At Helena, Ark., the discharges were taken on the same section as that used by Assistant L. E. Ritter during December, 1890. The signals were erected on the Arkansas shore, the pivot signal being 2,130 feet above the section line.

The observations were taken with Price meter No. 29 at $\frac{6}{10}$ depth.

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The rate of the meter remained constant.*

The steamer *H. M. Graham* was used for taking the discharge measurements till March 14, the arrangement of the meter outfit being the same as on the *Abbot*.

On March 17 the tug *Ida Patton* was used. The mast and boom derrick was erected on the stern of the tug, the boom projecting over the side and making an angle of about 60° downstream with the axis of the tug. The method of raising and lowering the meter and the electric connections were the same as on the *Graham*, except that a guy line from the bow of the tug held the meter vertical. On March 24 the outfit was replaced on the *Graham* and discharges taken in the usual manner.

The soundings were made with a three-eighths inch braided-cotton line and a 15-pound lead. On April 3 a check sounding was made with a steel wire and a 25-pound lead.

The details of the field work of a discharge are as follows: Tested lead lines, oiled meter, whirled it by hand and noted the number of seconds required to come to rest, in this case about 306 seconds. Gauge read to the nearest $\frac{1}{100}$ of a foot. Section sounded, the position of the boat being located by the sextant at moment of crossing the range.

The boat was taken to the first velocity station. The assistant engineer on the roof over the engineer. Engineer gets on range and holds it there, as nearly as possible. The leadsman tends to register, and when exactly on range the assistant engineer gives signal to commence the observation. Position located by the sextant. After two to five minutes, when the boat is right on range, the assistant engineer gives signal to stop the register. At completion the guage read again. The field work lasted from four to six hours, after which the tape was counted and checked and the observations calculated.

At Robertsonville crevasse the soundings and velocities were taken from a skiff and position located by transit and stadia. The skiff was held in position by a line which was made fast to a tree on upper or river side of crevasse. The meter was attached to piece of gas pipe about 20 feet long.

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Capt. S. W. Roessler,
Corps of Engineers, U. S. A., Memphis, Tenn.

* This statement is apparently based on the tests made by turning the meter wheel with the hand and noting the time it continued to revolve.

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EXTRACTS FROM REPORTS OF MR. WILLIAM GERIG, ASSISTANT ENGINEER, UPON THE FIELDWORK OF LOW-WATER DISCHARGE OBSERVATIONS AT CAIRO, ILLINOIS, ELMOT, ARKANSAS, MEMPHIS, TENNESSEE, AND HELENA, ARKANSAS.

MEMPHIS, TENN., *February 4, 1892.*

Assistant Engineer C. W. Sturtevant was in charge of the party and the fieldwork.

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Elmot, Arkansas.—At this point the meter method was used, meter being submerged at six-tenths depth, and the boat held on range with throttle valve. Range No. 37 was chosen for the discharge section. The soundings and velocity stations were located with a sextant.

Price meter No. 34 was used and was rated on September 23, 1891. The rating was made in still water, the meter being suspended from a cable track and pulled back and forth at various velocities. The length of the base was 259.12 feet, and the time was recorded by a break-circuit chronometer, No. 1344, manufactured by T. S. & J. D. Negus, the rate, gain per sidereal day, 1.2 seconds.

Memphis, Tennessee.—The party went to Memphis, and the first discharge was taken on September 29, 1891.

The meter method was used. The section was located at Hopefield, Ark., and about 5,000 feet above the Memphis and Little Rock Railway incline.

Eighteen discharge observations were made at this point. Five gauges were erected here for determining slope. The first or lower gauge was at the Memphis and Little Rock Railway incline. Surface velocities were measured here.

Gauge No. 2 was near the section and 4,300 feet above gauge No. 1. Gauge No. 3 was 5,500 feet above gauge No. 2. Gauge No. 4 was 3,250 feet above gauge No. 3. Gauge No. 5 was 8,800 feet above gauge No. 4. Surface velocities were measured at gauges 4 and 5.

Cairo, Illinois.—A discharge of the Ohio River and the two chutes of the Mississippi River was measured on November 11 and 12, 1891. The mid-depth float method was used. There were in use one skiff, two transits, one lead line and lead, one surface, and one submerged float.

* * * * * * *

Helena, Arkansas.—

MEMPHIS, TENN., *January 2, 1892.*

* * * * * * *

In accordance with your instructions I reported to Assistant C. W. Sturtevant, and he accompanied me to Helena, Ark., and assisted me to locate the section.

The party consisted of 1 assistant engineer, 2 observers, 1 leadsman, and 3 skiffmen.

The discharge section was located 4,500 feet below the wharf boat at Helena, Ark. The ends of the section were marked by range signals, those on the Arkansas side being called B and B′ and those on the Mississippi side being called C and D, the distance from B to C being 1,720 feet, and Station A was 1,442.3 feet above the section on Arkansas shore, and was occupied by one of the observers. From this station the soundings were located on the section line. The distance from water's edge to B and C was measured each day, which determined the river width.

The instruments used consisted of one surface float, tin, double cone-shaped, and about 4 inches in diameter; one submerged float, made of cypress, 12 by 12 by 36 inches, and was submerged to mid-depth; two transits, one watch, one sounding lead and lines, etc.

A discharge was taken as follows: Stations A and B occupied by observers, the assistant engineer is in skiff with watch and flag in hand. The skiff was rowed above the section, say, about 200 feet, and the float put overboard, and when it was floating good the assistant engineer gave the signal for the observers to locate the float, and at that moment the time was noted; at the expiration of one minute the assistant engineer gave the signal again, and the float was located and time recorded. Then the float was hauled into the skiff and rowed above section for a second float observation. Drifting soundings were taken on section line, and were located by Station A and recorded by the assistant engineer. One 20-pound lead and a three-eighths inch braided cotton line was used. The lead line was measured at the end of each day's work, and measurements entered in note books.

Several days previous to October 23 the bank at Station B began settling, and B′ was located in line with BC and 67½ feet westward from B. Station B′ was occupied after October 22 by the observer.

Slope measurements.—Gauges were erected at section, and one 8,658 feet below the section at the foot of the straight reach, and were read each day; the time of reading and the reading were entered in the notebooks. The gauge at section was called C, the lower one D. Surface velocities were measured each day at D and at wharf boat, where the United States gauge was read before and after taking the dis-

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charge. Gauge B was erected 9,700 feet above section, but was destroyed before the elevation of its zero could be established satisfactorily, and hence it was omitted in the final reduction. Gauge A was established 32,450 feet above discharge section on Arkansas shore. It was read as often as possible and the surface velocity measured and entered in notebook. The distance from Gauges A to D is 41,108 feet. The distance from United States gauge to D is 13,158 feet. The elevation of the zeros of the gauges were obtained by two sets of independent levels and taking the mean of the two.

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Capt. S. W. ROESSLER,
Corps of Engineers, U. S. A., Memphis, Tenn.

MEMORANDA TO ACCOMPANY TABULATED RESULTS OF FINAL REDUCTION IN SECRETARY'S OFFICE OF DISCHARGE OBSERVATIONS, CAIRO TO CARROLLTON, 1891.

When floats were used the velocities were found in the manner described in Mr. Sturtevant's report, page 3118, different scales, however, being used for the plots as noted for each station.

The methods of computing the quantities tabulated are the same as heretofore used in similar cases and fully described in previous office memoranda published in the annual reports of the Commission.

Cairo, Illinois.—Double floats were used at this station and their paths plotted to scales of 1 inch to 50 feet and 1 inch to 100 feet for the Mississippi and Ohio rivers, respectively. The cross sections were plotted to a scale of 1 inch=100 feet horizontal and 1 inch=10 feet vertical. Soundings midway between velocity stations were scaled off from these plots and used with the observed soundings to compute the partial areas.

Columbus, Kentucky.—Discharges were measured at this station by Assistant Engineer L. E. Ritter, from February 27 to March 4, with a current meter; and by Assistant Engineer C. W. Sturtevant, from March 11 to 25, with double floats. The same section was used by both parties but with different shore signals.

Soundings were at irregular intervals across the river, and for Mr. Ritter's set soundings midway between velocity stations were interpolated from the two adjacent soundings for computing the partial areas.

Price meter No. 29 was used at six-tenths depth; the length of an observation varied from two to ten minutes, but was generally three or four minutes. For reducing registrations to velocity the combined results of ratings of December 3 and 27, 1890, were used, the equation being $y=4.1419\ x+0.361$, in which y equals velocity in feet per second and x equals registrations of meter per second.

In Mr. Sturtevant's set, the float paths were replotted to a scale of 1 inch=200 feet.

The soundings had been plotted in the field on cross-section paper, scale 1 inch to 200 feet horizontally and 1 inch to 20 feet vertical. The plotting was checked in this office from the notebooks, and then soundings were scaled off from the plots at every 50 or 100 feet and partial areas computed. The float velocities were plotted on these cross sections to a vertical scale of 1 inch to 2 feet per second and the points connected by straight lines, forming a transverse curve of velocity. From this curve a velocity was scaled off at every other ordinate at which a sounding had been scaled and the velocity so obtained applied to the partial area extending half way to the next velocity station on either side, the interval between these scaled velocities being 100 feet near the shore and where rapid changes in velocity curves appeared; but generally the interval was 200 feet.

Datum line was taken at 40.55 feet on the Belmont gauge throughout the season and datum width at 3,121 feet. These were the observed stage and width on March 11. There was a higher gauge reading in Mr. Ritter's set, but his notes were not received until after Mr. Sturtevant's set had been reduced.

Elmot, Arkansas.—For the high-water discharges observations were made on the main river and the two chutes, and for the low water on the main river only. The discharge sections on the main river were about 2,000 feet apart, the high-water section being above and the low-water section below Elmot landing. In the high-water series Price meter No. 29 was used. (For value of meter constants see rating used at Helena, page 3122.) The meter was run at six-tenths depth and generally for three or four minutes. The velocity stations were always at the same places and generally 200 feet apart. On the main river soundings were at the velocity stations and midway between them. The partial areas were computed directly from the soundings and the observed velocities applied to the corresponding partial areas. The stations in the chutes were at irregular distances apart. Discharges were com-

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puted in the same way as for the main river. The datum line was taken at the observed reading of January 7, 17.76 feet on the local gauge. In the reduction of the low-water observations (for field report see page 3120) the cross sections were plotted to a scale of 1 inch to 200 feet horizontal and 1 inch to 10 feet vertical. The transverse curves of velocity were plotted on the cross sections in terms of meter registrations, the scale being approximately 1 inch = 1 foot velocity per second. Velocities were scaled from this curve every 200 feet, or, where the curve was irregular, 100 feet. Soundings were scaled every 50 feet. The end velocity stations were 30 or 40 feet from shore, and observed velocities were applied to end areas. The discharges were computed same as described for Helena high-water series. Since the velocities of discharges were low the rating observations, ranging from 0.86 to 4.80 feet, were selected for computing the rate of the meter (for results of reduction see table). Datum line in the low-water series is taken at 2.80 feet on the local gauge.

Fulton, Tennessee.—Velocities were measured with double floats, same as described for Columbus, Ky., and were also reduced in the same manner; only one discharge was observed.

Memphis, Tennessee.—The high-water discharge section was at the same place as in 1890, about 3,500 feet above the bridge. The low-water section was near Hopefield, and about 2¾ miles above the high-water section. (For field reports see page 3120.) In the high-water series the areas were computed from the soundings as taken, the distances apart being computed, and the discharges were found, in the usual manner, directly from the observed velocities. In the low-water series the cross sections were plotted and also the transverse curves of velocity, and from these plots velocities were scaled off every 100 and soundings every 50 feet; from these the discharges were computed in the same way as described for Helena high-water series. On the shallow side, the end velocity station was generally about 300 feet from shore, with a sounding of about 10 feet; two-thirds of this observed velocity was applied to the end area; on the deep side of the river the distance out was about 100 feet, and four-fifths of the observed velocity at this point was applied to the end area. For results of rating meter No. 34 see table of meter ratings. Datum line taken at 3.65 feet on the standard gauge at Memphis, which was the mean of 8 a. m. and 4 p. m. readings September 29, 1891.

Helena, Arkansas.—The high-water section, 1891, is about 7,200 feet below the wharf boat and at the same place as the low-water section of 1890; the high-water section of 1890 was about 900 feet below the wharf boat. The low-water section of 1891 is about 4,500 feet below the wharf boat. (For field reports see page 3120). For high-water observations the sounding and velocity stations were located on the section line by sextant angles and at irregular intervals across the river. The distances out were computed and the areas between soundings found; these areas were summed in a series of partial areas to correspond with the velocity stations, each partial area extending on either side of the corresponding velocity station half way to the next station. Each of these partial areas was multiplied by the registrations of the meter at the corresponding station, reduced to one second of time. These partial products were summed and multiplied by the value of the meter constant *a*. The total area was multiplied by the meter constant *b*; the sum of these two products is the total discharge in cubic feet per second. On the Arkansas side of the river the distance out of the first velocity station was generally 400 or 500 feet, except on three days, when it was about 300 feet. For the first 200 feet of this distance, or as far as the river bank proper, the water was only 4 feet deep, but it then became very deep, the sounding at the first velocity station being usually about 80 feet deep at 400 or 500 feet out. Where the distance out of the velocity station was about 400 feet or over, two-thirds of the observed velocity was applied over the end area as done heretofore in similar cases, the observations on the three days above mentioned agreeing well with this. On the Mississippi side of the river the last velocity station was generally 300 to 400 feet from shore, except on four days when the distance was about 200 feet. The mean of these four days was used as velocity at this distance for the other days.

The sounding at the last velocity station was about 22 feet.

The time the meter was run at each station varied from two to seven minutes, but was generally about two and a half minutes.

Since no observations were made for rating the meter this year, the equation $y = 4.1419\ x + 0.361$ (in which y = velocity in feet per second and x = registrations of meter per second) was used in computing the present set of discharges; the values of the meter constants in this equation were derived from reduction in this office last season of rating observations of December 3 and 27, 1890.

In computing datum areas the datum line is taken at 44.70 feet on the Helena gauge, and datum width at 5,800 feet; these were the observed stage and width March 26.

The other quantities tabulated have been found in the usual way, which has been fully described in previous office reports.

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In the low-water series double floats were used; the method of reduction is similar to that described for Columbus, Ky. The float paths were plotted to a scale of 1 inch to 100 feet, and the cross sections to the same horizontal scale and to a vertical scale of 1 inch to 20 feet for soundings and 1 inch to 1 foot for velocities. The soundings were scaled off every 50 feet and the velocities every 100 feet, except where the curves were irregular, when one-half the distance was taken.

The distances out of the end velocity stations varied, but were generally less than 100 feet from shore; on the shallow side two-thirds of this observed velocity was applied to the end area and on the deep side four-fifths

The low-water section is about one-half mile above the high-water section. The datum line is taken in the low-water series at 4.73 feet on the standard Helena gauge, and the datum width as 1,656 feet, both as observed on September 30, 1891.

Robertsonville crevasse, 353.8 miles below Cairo.—Two sets of soundings and velocities were observed on the same day, both sets of soundings were combined in computing the area, but the velocities were applied separately, giving two discharges.

In transmitting the field notes of these observations the district officer states: "The crevasse measurement is of doubtful accuracy on account of the existence of an eddy in the gap between the ends of the standing levee, in which the discharge section was located."

Arkansas City, Arkansas.—The discharge section intersects the Arkansas shore at the same point, and the Mississippi shore at a point 100 feet below the section of 1889 and 1890.

The soundings were at irregular intervals across the river, and were located on the range by transit angles, the transit being at the end of a 2,000-foot base on the Arkansas shore.

These soundings were plotted, after being corrected for error of lead line, and ordinates scaled from these cross sections every 50 feet, and tabulated for computing the areas; the discharges being computed in the same manner as described for Wilson Point.

The velocity stations were at fixed points 300 feet apart on the section, except Stations I and II, near the Mississippi shore. Until March 25 Station I was 90 feet from the bank, but after that date, on account of snags near the bank, velocities for Station I were generally taken 152 feet from bank, and only 12 feet below the surface, the depth at that point being about 40 feet. Velocities for several days were also observed at six-tenths depth 128 feet from the bank. The observer remarks that this was the "center of mass of the partial section." From these observations velocities were deduced for the point 90 feet from the bank at six-tenths depth. The observer estimates the velocity at the Mississippi bank to be five-tenths or six-tenths of that observed at 152 feet out. It was assumed that the mean velocity for 131 feet out was one-half the velocity observed at 152 feet from the bank.

From March 25 to April 20, inclusive, observations for Station II were taken at 376 feet instead of 330 feet from the bank, the latter being the regular distance. For these days velocities at 330 feet were deduced from velocities observed at 376 feet.

Station XII was 96 feet from the Arkansas bank, and the velocity observed at this station was applied from the bank to midway between Stations XII and XI. On May 1 and 5 float observations were made for determining the direction of the current near the discharge section; the plots show the average direction of the floats to be about 10° 30′ from a normal. This indicates that the velocity as observed on the cross section is about 1¼ per cent too large, but no correction has been made for this in the final reduction.

The velocities were observed with the Price current meters at six-tenths depth, and generally for five minutes at each station. Meters Nos. 4, 5, and 6 were used during the season; the results of the ratings are given on page 3143. For notes on these meters see under Wilson Point, and also report of Mr. Hoopes in Report Chief of Engineers, 1891, page 3660.

For measuring discharges the meters were used as follows: Meter No. 4, March 25 and 27, May 2 to 7; meter No. 5, March 6 to 11, and March 28 to April 30; meter No. 6, March 12 to 24 and May 8 to 12, dates inclusive. The rating nearest in date was used for each discharge (except where meter was cleaned or altered), the same as at Wilson Point.

Meter No. 4 was rated March 26, but the results were so discordant they could not be used; the discharges measured with this meter March 25–27 are apparently worthless, and are not printed; the observer also rejected them on account of their discordance.

The datum line is taken at 41.73 feet on the standard gauge as tabulated; datum width taken as 3,416 feet, which was the observed width May 8. For reports on field-work see Report Chief Engineers, 1891, pages 3658 and 3660.

Wilson Point, Louisiana, low water of 1890, and high and low waters of 1891.—The discharge section used is 100 feet above the section used during high water of 1890.

The soundings were at irregular intervals across the river; in 1890 these soundings

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were located by transit angles from the end of a 1,600-foot base on the Louisiana shore; in 1891 they were located from the boat by sextant angles to 1,000-foot bases, one base on either shore, each base being used half way across the river. On April 30 the soundings were located simultaneously by the two methods, the transit on shore with 1,600-foot base, and the sextant in boat to 1,000-foot base; the results show a close agreement, the difference ranging from 0 to 39 feet, the latter being, however, exceptional, generally the difference not exceeding 6 feet; the mean difference of 94 sets, including the extreme case above noted, is 2.3 feet.

The distances out of the soundings were computed and cross sections plotted to a scale of 1 inch to 200 feet horizontal and 1 inch to 20 feet vertical. From these plots ordinates were scaled off at intervals of 50 feet, arranged so that every seventh scaled sounding coincided with a velocity station. These scaled soundings were tabulated and the partial areas computed.

The velocity stations were 300 feet apart (except Stations I and II, which were 250 feet) and always at the same place. The end velocity stations in the high-water observations were 88 and 154 feet from the Mississippi and Louisiana shores, respectively. In the low-water sets the distances from shore varied from 50 to 250 feet.

The velocity as observed at each station was applied to the corresponding partial area; this partial area extended on either side of the station half way to the adjacent stations. Each partial area was multiplied by the registrations per second of the meter at the corresponding station and the sum of these partial products was multiplied by the value of the meter constant *a;* to this product was added the area multiplied by the meter constant *b*, the sum being the total discharge per second.

During the high water the entire banks between the main levees were overflowed. The field notes of this discharge over banks being incomplete, the field results were adopted and are given in the tabulation as made up by the observer, who evidently interpolated for days when it was not observed.

The Price current meter No. 6 was used for all the high-water observations except May 7, when No. 5 was used. No. 5 was also used for all the low-water observations.

The meters were rated frequently and the results, derived from final reduction in this office by the method of least squares, are given in the appended table, page 3143. The table shows that the rates of the same meters are very different. In seeking to explain these differences Mr. T. C. J. Bailey, who was assistant to the surveyor, Mr. Richards, during time observations were taken, under date of January 4, 1892, writes: "The larger values of the coefficients *a* and *b* for meter No. 5 found at Huntington from those found at Wilsons Point, I think, are due to the fact that at the former place only the lower bearings were oiled, for fear of injuring the electrical connection, while at the latter place both bearings were oiled.

In the case of meter No. 6, both upper and lower bearings were oiled, except in the rating of May 8, 1891, when only the lower ones were. I have found that the stiffness of the oil used has a marked effect upon these coefficients. It has been our practice recently to use pure vaseline in the upper bearings and sperm oil in the lower, although I believe good sperm or watch oil to be preferable both above and below. Probably, however, the differences in the ratings are due more to unequally worn bearings than to any other cause. It is found that with the same impulse meter No. 6 spins different lengths of time at different inclinations, spinning the longest held with both axes horizontal, an indication of bad bearings. The base lines were checked before each rating, and being temporary could not now be remeasured."

From the foregoing, it appears that the meters were not always in the same condition, hence it was decided to use the rating for each discharge, nearest in date to that discharge observation. This was also done in the last low-water series, since a very marked difference appears in the rate of meter No. 5 after it was reported as being thoroughly cleaned.

The field notes of the low-water observations of 1890 were received in this office for reduction January 11, 1892, together with notes of a meter rating of January 19, 1891; this rating was used in computing the three discharges.

The meter was generally run for five or six minutes at each velocity station and at six-tenths depth for all the work. January 9, 1892, the third district officer, referring to these meters, states that he considers them unreliable and has ordered two new ones. (For field reports see Report Chief Engineers, 1891, page 3658.)

In all the earlier series at this place, the readings tabulated under "local gauge" are elevations of the water surface, at the discharge section, above a plane at the same elevation as the zero of the Lake Providence gauge, which is 89.62 feet above the Cairo datum plane, survey Mississippi River.

It appears from levelings to bench marks in April, 1892, that a change was made in the local guage in 1890, which affected the readings beginning with the low water of that year; this error has been corrected in the tabulation for the low-water series, but the high-water series was already computed and printed, and since the error only affected the datum quantities, no correction has been made. Therefore, to re-

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duce the local gauge readings of this high-water series to agree with the low-water series, and also with former publications, subtract 0.25 of a foot. The datum line has been taken at 41.83 feet on the local gauge as tabulated. The datum width has been taken as 3,788 feet, and the slope of the banks assumed to be uniform down to 10.5 feet on the local gauge, at which height the width has been taken as 3,632 feet for computing the datum areas of the last low-water series.

On October 19 the subsurface floats were run to determine the direction of the current near the discharge section. The results showed the general direction of the current to be about 12° from a normal, the deflection being all in the same direction. This would indicate that the discharges, as computed from meter observations on the section are about 2 per cent too large; no correction, however, has been applied for error from this source.

The observer attributes the deflection of the current to the presence of bars above and below the discharge section.

Louisiana Bend, Louisiana.—One discharge was measured here October 19, 1891; the velocity stations were from 150 to 300 feet apart. The reduction was made in the same way as for Wilson Point.

Natchez, Mississippi.—The velocity and sounding stations were coincident and always at the same places. They were located on the section by means of fixed signals on shore, and from April 4 a sextant was used in addition to the range signals. The distance between stations varied from 98 to 233 feet; the end stations were about 60 and 80 feet from shore.

The Price meter No. 25 was run at each station for two and three minutes. At Stations 4 to 9, covering the deepest part of the river, the meter was at two-tenths depth, and at stations nearer shore was at from three-tenths to six-tenths, except on one day when Stations 1 and 2 were taken at seven-tenths depth. The note book contains a table of coefficients to reduce velocities at different depths to velocity at six-tenths depth, which was stated to be derived from observations of Mr. Price in 1883. This table was used in the final reduction and is as follows: To reduce velocities to six-tenths depth multiply by the following co-efficients:

Two-tenths, depth	0.986
Three-tenths, depth	0.984
Four-tenths, depth	0.9875
Five-tenths, depth	0.996
Seven-tenths, depth	1.015

Since the sounding and velocity stations were coincident, the mean of the velocities, as observed or reduced, at two consecutive stations, was applied to the included area. The discharges so obtained were corrected approximately by the same formula as in 1889 and 1890; the correction was from + 2,000 to + 3,000 cubic feet per second for a total discharge. Four-fifths of the velocities observed at the end stations was applied to the end areas. The datum line was taken at 46.50 feet on the gauge, and the datum width as 2,135 feet; both as observed on April 11.

The rating of meter No. 25, March 25, 1891, was used, see table of ratings for values. The rating of March 8, 1890, $y = 3.9515x + 0.393$, was used for meter No. 23. Mr. B. J. Oliveira was observer until April 3; after that Mr. G. Ed. Mott was the observer. Slope observations were made at time of discharge measurements, but the level connections between the gauges was not made until March and April, 1892. The results are given in the accompanying slope table.

Red River Landing, Louisiana.—The discharge section was at the same place as in 1889 and 1890.

The velocity and sounding stations were coincident and at the same places on the section. Stations were 200 feet apart except near the shore they were 100 feet apart. The end stations were about 80 and 100 feet from shore in the high-water series, in the low-water series the station nearest the left bank was about 330 feet from shore, the sounding at that point being only about 7 feet, at the other side the distance out was about 116 feet.

The meters were run for three minutes at six-tenths depth; meter No. 23 being used for high-water, and No. 25 for low-water series. For No. 23 the results of rating of March 8, 1890 ($y = 3.9515x + 0.393$), were used. For No. 25 same values as for Natchez were used.

The discharges were computed in the manner described for Natchez. The formula correction varied from about — 300 to + 800 cubic feet per second for each total discharge.

Datum line taken as formerly, at 48.50 feet on the standard gauge, datum width assumed to be 3,995 feet at that height and 3,860 feet at 24 feet on the gauge, for computing datum areas.

The discharge over bank was on line of discharge section on the right bank and partly around the end of an old levee; the discharge was all between the main levees.

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Mr. G. Ed. Mott was observer until April 2 and on April 20; Mr. W. G. Price was observer from April 7 to 16; Mr. B. J. Oliveira was observer during low water.

The slope-gauge observations were made in April, 1891, and the level connections made in March, 1892, by Mr. G. Ed. Mott.

Simmesport, Louisiana.—The high-water discharge section was at the same place as in 1889 and 1890, that is, about 700 feet below Dam No. 3. The observer states that the low-water section is about midway between Dams Nos. 1 and 3.

The sounding and velocity stations are coincident and mainly 100 feet apart; near the shores they are about 50 feet apart.

Price meter No. 23 was used for all discharges, except April 27, when No. 25 was used; for rating of No. 25 see table. For meter No. 23, the equation $y = 3.9515\ x + 0.393$ was used for the high-water discharges, and $y = 4.1701\ x + 0.188$ for the low-water discharges; these are derived from rating observations of March 8, 1890; the first using all the observations, and the second using a group of the lowest velocities, since the river velocities were very low, during low water being less than 1 foot per second, while the lowest velocity observed in the rating was 1.6 feet per second.

The meters were run at six-tenths depth except on April 13, when the meter was at four-tenths depth; to reduce this to six-tenths depth, .013 of the observed velocity was deducted.

The time of an observation was three minutes at each station, except in a few cases, when the time was six minutes. The discharges have been computed in the same manner as described for Natchez. The formula correction was from 0 to + 1,200 cubic feet per second for the high-water discharges; no correction was applied to the low-water discharges. The high-water datum line is taken at 32.30 feet on the standard Simmesport gauge and the datum width as 885 feet. The low-water datum line is taken at 0.1 foot on standard Simmesport gauge, the low-water readings, as tabulated, are taken from the standard record, since the gauge record in the field book was incomplete; the low-water datum width is taken at 752 feet, as observed October 16, 1891.

Mr. G. Ed. Mott was the observer from March 9 to 30 and on April 17; Mr. W. G. Price was observer from April 4 to 15; Mr. R. Y. Briggs was observer April 27 and October 16 to November 20.

Slope was observed at the time of high-water discharges, and the level connections made by Mr. Mott after the water had receded.

Carrollton, Louisiana.—The sketch of discharge section accompanying the field notes shows the Carrollton section at apparently the same place as in 1890; discharges were also measured at Henry Clay avenue, which is about 2¼ miles below the regular section and about one-quarter mile below the lower end of the Ames Crevasse; for field report of Mr. William Garvin, assistant engineer, see Report Chief Engineers, 1891, page 3715.

The sounding and velocity stations are coincident, and at the Carrollton station from 30 to 200 feet apart; mainly being 100 or 200 feet apart.

At Henry Clay avenue they are 100 feet apart. The end stations are about 100 and 180 feet from shore at Carrollton, and 56 and 85 feet at Henry Clay avenue.

Price meter No. 22 was run at six-tenths depth and for two minutes at each station; see table of meter ratings for values of constants.

The discharges have been computed in the same way as at Natchez. The formula correction was from + 1,200 to + 2,500 cubic feet per second for each total discharge at Carrollton and from + 500 to + 2,100 at Henry Clay avenue. Four-fifths the velocity observed at the end stations was applied to the end areas, except at the Carrollton station 180 feet out, for which two-thirds velocity was used.

At Carrollton the datum line is taken at 13.54 feet and datum width at 2,365 feet; at Henry Clay avenue the same datum line is taken and datum width at 2,080 feet, the standard Carrollton gauge being used for both sections in the tabulation.

The observer attributes the large variations in discharges obtained at Henry Clay avenue, to the eddies or irregularities in the current produced by the crevasse.

When not otherwise stated, results given in this appendix are derived from final reduction at the office of the secretary, Mississippi River Commission.

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Results of discharge observations, Ohio and Mississippi rivers, Cairo, Ill., and Columbus, Ky.

CAIRO, ILLINOIS.

[Velocities measured with double floats.]

Date.	Gauge.		Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard.	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.						
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							
1891.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			
Nov. 11*	†2.87	....	58,350	....	27.5	....	36.8	2,122	....	0.715	41,701	13	16	X—Light.
11‡	†2.87	....	8,539	....	10.6	....	14.3	806	....	5.151	43,987	7	13	
11§	†2.87	....	6,655	....	7.0	....	14.8	950	....	4.285	28,515	9	13	
Total	....	....	73,544	....	....	....	....	....	....	....	114,203	....	....	

COLUMBUS, KENTUCKY.

[Velocities measured with Price current meter until March 4; from March 11 to 25 with double floats.]

Date.	Standard.	Rise or fall in the preceding 24 hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
Feb. 27	‖40.47	+0.2	185,605	185,854	59.7	59.5	80.5	3,111	....	7.054	1,309,312	10	42	V—Strong.
28	40.75	+0.3	188,981	188,358	60.7	60.4	78.5	3,113	+2,504	7.215	1,363,547	10	37	X—Moderate.
Mar. 1	40.95	+0.2	186,548	185,298	59.6	59.4	80.0	3,128	−3,060	7.404	1,381,217	10	40	XII—Moderate.
2	41.12	+0.2	185,340	183,559	59.2	58.8	81.5	3,129	−1,739	7.393	1,370,223	11	36	II—Moderate.
3	41.25	+0.1	187,439	185,250	59.8	59.4	83.0	3,132	+1,691	7.350	1,377,690	11	35	X—Moderate.
4	41.27	0.0	186,826	184,575	59.7	59.1	80.0	3,132	− 675	7.376	1,377,966	11	35	IX—Moderate.
11	40.55	−0.2	185,030	185,030	59.3	59.3	81.0	3,121	+ 455	6.426	1,189,066	21	24	Variable.
12	40.42	−0.1	189,085	189,490	60.6	60.7	83.0	3,118	+4,460	6.481	1,225,464	20	19	N—Strong.
13	40.36	0.0	187,766	188,358	60.2	60.4	83.0	3,117	−1,132	6.618	1,242,634	21	30	N.
14	40.27	−0.1	186,286	187,158	59.8	60.0	82.5	3,116	−1,200	6.547	1,219,611	18	29	Calm.
15	40.20	−0.1	185,444	186,535	59.5	59.8	82.5	3,116	− 623	6.410	1,188,705	18	19	
16	40.20	0.0	188,480	189,571	60.5	60.7	82.5	3,116	+3,036	6.589	1,241,852	20	31	
17	40.20	0.0	187,722	188,813	60.2	60.5	82.5	3,116	− 758	6.314	1,185,220	20	26	Calm.
18	40.20	0.0	188,198	189,289	60.4	60.7	82.0	3,116	+ 476	6.382	1,201,122	20	20	N. & E—Light.
20	40.18	0.0	189,548	190,701	60.8	61.1	82.0	3,116	+1,412	6.458	1,224,087	18	24	S. W—Light.
22	40.00	−0.1	181,025	182,739	58.1	58.6	¶81.0	3,116	−7,962	6.272	1,135,416	19	27	
23	39.98	0.0	183,819	185,595	59.0	59.5	79.5	3,116	+2,856	6.429	1,181,718	18	29	
24	39.82	−0.2	184,503	186,778	59.2	59.8	80.0	3,116	+1,183	6.264	1,155,758	19	24	S—Light.
25	39.65	−0.2	184,889	187,093	59.3	60.1	80.0	3,116	+ 915	6.319	1,168,366	19	37	E—Light.

* Ohio River.
† Cairo gauge.
‡ Mississippi River, Cairo or left chute.
§ Mississippi River, Missouri or right chute.
‖ Belmont gauge.
¶ Chief of party states that the maximum sounding (81 feet) was adopted from the observations of the preceding day.

Results of discharge observations, Mississippi River, Plum Point Reach.

Location.	Date.	Gauges. Local.	Gauges. Fulton.*	Gauges. Rise or fall in the preceding 24 hours.	Mean depth.	Mean datum depth.	Maximum depth.	Width.	Scour or fill.	Mean velocity per second.	Water area.	Datum area.	Discharge per second.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	1891.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Square ft.*	*Feet.*	*Square ft.*	*Square ft.*	*Cubic feet.*			
Main River	Jan. 6	17.32	20.1	−0.55	37.4	37.8	47.0	2,732	....	5.431	102,174	103,376	554,929	13	30	XII—Light.
Elmot Chute	Jan. 6	17.32	20.1		......	......			....					......	......	
Island No. 30	Jan. 6	17.32	20.1		11.6	12.0	15.0	947	....	3.414	10,991	11,409	37,526	4	11	Calm.
Main River	Jan. 7	17.76	20.6	− .45	38.0	38.0	47.0	2,733	+ 527	5.408	103,903	103,903	561,903	15	31	XII—Moderate.
Elmot Chute	Jan. 7	17.76	20.6		13.6	20.4	35.0	1,398	....	1.891	18,987	17,882	35,898	5	21	IX—Moderate.
Island No. 30	Jan. 7	17.76	20.6		12.3	12.3	15.0	951	+ 325	3.571	11,735	11,735	41,911	6	12	Do.
Total	....	......	......	......	......	......	......	5,082	....	....	134,625	....	639,712	......	......	
Main River	Jan. 26	13.10	16.5	− .82	32.9	37.1	41.0	2,696	− 487	5.082	88,766	101,416	451,122	15	36	VI—Light.
Elmot Chute	Jan. 27	12.50	15.9	− .60	17.0	21.4	33.0	880	+1,825	1.414	14,968	19,707	21,160	3	18	IV—Light.
Island No. 30	Jan. 26	13.10	16.5	− .82	7.5	11.9	12.0	929	− 392	3.275	6,963	11,343	22,805	6	16	VI—Light.
Total†	....	......	......	......	......	......	......	4,505	....	....	110,697	....	495,087	......	......	
Main River	Jan. 28	12.45	15.8	− .14	32.1	36.9	40.0	2,695	− 602	4.659	86,403	100,814	402,545	14	37	II—Light.
Elmot Chute	Jan. 28	12.45	15.8	− .14	16.7	21.1	32.5	880	− 207	1.162	14,716	19,500	17,107	3	17	Calm.
Island No. 30	Jan. 28	12.45	15.8	− .14	6.5	11.6	12.0	928	− 286	3.257	6,068	11,057	19,761	5	16	VI—Light.
Total	....	......	......	......	......	......	......	4,503	....	....	107,187	....	439,413	......	......	
Main River‡	Sept. 19	2.80	7.2	− .4	26.6	26.6	34.0	2,386	....	2.433	63,554	63,554	154,599	13	45	Calm.
	Sept. 21	2.30	6.7	− .2	25.9	26.4	34.0	2,385	− 595	2.215	61,766	62,959	136,797	12	40	Do.
	Sept. 22	2.10	6.5	− .2	26.2	26.9	32.0	2,385	+1,146	2.407	62,435	64,105	150,290	15	46	
	Sept. 26	1.45	5.9	− .2	26.3	27.6	32.0	2,387	+1,825	2.192	62,708	65,930	137,483	12	37	
	Nov. 5	− 1.48	2.9	− .1	21.8	25.9	29.0	2,376	−4,039	1.580	51,698	61,891	81,658	15	50	Do.
	Nov. 6	− 1.56	2.8	− .1	21.1	26.3	30.0	2,376	+ 922	1.570	52,430	62,813	82,296	13	46	Do.
	Nov. 10	− 1.59	2.8	.0	22.4	26.7	28.5	2,377	+ 800	1.552	53,158	63,613	82,480	12	45	Do.
	Nov. 11	− 1.58	2.8	.0	22.1	26.4	28.0	2,377	− 642	1.510	52,540	62,971	79,352	14	52	Do.

*Standard gauge whose zero is 228.55 feet above the Cairo datum plane, survey Mississippi River.

†If the quantities for Elmot Chute are corrected for change of stage (0.6 feet) to agree with the 26th, the area and discharge would be increased 528 square feet and 747 cubic feet, and the totals would become 111,225 square feet and 495,834 cubic feet.

‡At Elmot Landing. This is total discharge of river.

NOTE.—Velocities measured with the Price current meter.

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Results of discharge observations, Mississippi River.

FULTON, ARK.

Date.	Gauge. Standard.	Gauge. Rise or fall in the preceding 24 hours.	Cross section of discharge. Area. Water.	Cross section of discharge. Area. Below datum.	Cross section of discharge. Depth. Mean.	Cross section of discharge. Depth. Mean datum.	Cross section of discharge. Depth. Maximum.	Cross section of discharge. Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
1891.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Square ft.*	*Feet.*	*Cubic feet.*			
Apr. 1	32.22	—0.1	155,162	....	60.0	....	82.7	2.585	....	7.013	1,088,203	17	32	

MEMPHIS, TENN.*

Date.	Standard.	Rise or fall.	Water.	Below datum.	Mean.	Mean datum.	Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
Mar. 6	34.00	+.2	148,777	....	52.8	....	106.0	2,819	....	8.587	1,277,522	13	26	
7	34.31	+.3	142,409	....	50.5	....	103.5	2,819	....	8.653	1,232,325	12	25	
10	34.90	+.1	151,972	....	54.0	....	106.0	2,814	....	8.479	1,288,589	14	26	X—Mild.
Sept. 29	3.65	—.2	69,755	69,755	38.1	38.1	74.0	1,829	....	1.785	124,530	12	41	II—Strong.
30	3.45	—.2	70,258	70,624	38.4	38.6	71.0	1,829	+ 869	1.705	119,789	13	43	VI—Light.
Oct. 1	3.17	—.3	69,750	70,628	38.1	38.6	74.0	1,829	+ 4	1.688	117,741	10	39	VI—Strong.
2	2.95	—.2	68,202	69,482	37.3	38.0	75.0	1,829	—1,146	1.730	117,963	10	33	
3	2.75	—.2	68,905	70,536	38.4	38.6	76.0	1,795	+1,054	1.667	114,834	9	30	
4	2.60													
5	2.45	—.1	66,690	68,860	37.3	37.6	76.0	1,788	—1,676	1.815	121,017	8	28	Calm.
6	2.25	—.2	65,952	68,482	36.9	37.4	69.0	1,786	— 378	1.673	110,370	8	30	Do.
7	2.00													
8	1.90	—.2	67,835	70,998	38.0	38.8	71.0	1,786	+2,516	1.487	100,847	8	32	Do.
9	1.82	—.1	66,040	69,335	37.3	37.9	71.0	1,772	—1,663	1.521	100,475	10	31	II—Strong.
10	1.68	—.2	64,790	68,333	36.6	37.4	67.0	1,768	—1,002	1.450	93,954	9	27	II—Light.
11	1.60													
12	1.37	—.2	64,220	68,315	36.4	37.4	68.5	1,763	— 18	1.413	90,717	10	28	Calm.
13	1.30	—.1	64,013	68,232	36.3	37.3	66.5	1,762	— 83	1.527	97,740	8	29	
14	1.30	0	64,170	68,385	36.5	37.4	67.5	1,758	+ 153	1.490	95,605	8	29	XII—Slight.
15	1.35	0	64,120	68,246	36.5	37.3	71.0	1,759	— 139	1.519	97,393	11	32	Calm.
16	1.40	0	65,110	69,149	37.0	37.8	69.5	1,761	+ 903	1.401	91,213	10	25	VI—Light.
17	1.55	+.2	65,560	69,351	37.2	37.9	70.0	1,762	+ 202	1.484	97,338	9	29	Calm.
18	1.70													
19	1.85	+.2	66,655	69,897	37.6	38.2	70.0	1,773	+ 546	1.636	109,071	10	40	XII—Light.
20	2.00													
21	2.05	0	64,385	67,271	36.2	36.8	70.0	1,778	—2,626	1.613	103,858	10	29	II—Light.

NOTE.—Meter at six-tenths depth.

* The low water section is about 2¾ miles above the high water section, see memoranda.

HELENA, ARKANSAS.

[Velocities measured with the Price current meter at six-tenths depth as mean velocity at each velocity station.]

Date.	Gauge.		Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Number of velocity station.	Number of soundings.	Direction and force of wind.
	Standard.	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.						
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							
1891.	Feet.	Feet.	Sq. feet.	Sq. feet	Feet.	Feet.	Feet.	Feet.	Square ft.	Feet.	Cubic feet.			
Mar. 11	43.52	+0.1	217,557	224,398	37.5	38.7	82.0	5,795	....	6.081	1,322,913	16	39	IV—Medium.
12	43.62	+0.1	218,741	225,002	37.7	38.8	83.0	5,795	+ 604	6.240	1,365,005	17	42	II—Strong.
13	43.71	+0.1	219,527	225,267	37.9	38.8	85.0	5,796	+ 265	6.233	1,368,222	20	50	Calm.
14	43.78	+0.1												
15	43.85	0.0												
16	43.90	+0.1												
17	43.99	+0.1	220,903	225,020	38.1	38.8	85.0	5,797	− 247	6.238	1,377,883	19	42	Very little.
18	44.03	+0.1	223,292	227,177	38.5	39.2	85.0	5,797	+2,157	6.468	1,444,260	16	47	V—Moderate.
19	44.10	+0.1	221,696	225,175	38.2	38.8	85.0	5,797	−2,002	6.264	1,388,605	20	44	VII—Strong.
20	44.18	+0.1	224,972	227,988	38.8	39.3	85.0	5,799	+2,813	6.319	1,421,578	17	53	Calm.
21	44.28	+0.1	225,765	228,201	38.9	39.3	85.0	5,799	+ 213	6.443	1,454,541	20	44	IX—Very strong.
22	44.38	+0.1	223,272	225,128	38.5	38.8	85.0	5,799	−3,073	6.419	1,433,145	19	48	V—Very little.
23	44.44	+0.1	222,334	223,842	38.3	38.6	85.5	5,799	−1,286	6.390	1,420,776	18	52	X—Very mild.
24	44.52	+0.1	224,940	225,984	38.8	39.0	86.0	5,800	+2,142	6.340	1,426,215	18	44	I—Strong.
25	44.67	+0.2	224,144	224,318	38.6	38.7	86.0	5,800	−1,666	6.364	1,426,369	22	48	II—Mild.
26	44.70	0.0	227,405	227,405	39.2	39.2	85.0	5,800	+3,087	6.256	1,422,738	22	43	IX—Strong.
27	44.70	0.0	225,543	225,543	38.9	38.9	86.0	5,800	−1,862	6.352	1,432,664	21	42	Do.
28	44.68	0.0	229,477	229,593	39.6	39.6	86.0	5,800	+4,050	6.248	1,433,852	19	47	VIII—Mild.
29	44.62	−0.1												
30	44.68	+0.1	223,520	223,636	38.5	38.6	86.0	5,800	−5,957				44	VII—Strong.
31	44.67	0.0	226,999	227,173	39.1	39.2	87.0	5,800	+3,537	6.257	1,409,621	20	47	VIII—Strong.
Apr. 1	44.59	−0.1	224,843	225,481	38.8	38.9	87.0	5,800	−1,692	6.210	1,406,924	20	48	III—Medium strong to very light.
2	*44.52	−0.1	227,131	228,175	39.2	39.3	86.0	5,800	+2,694	6.348	1,441,722	18	42	XI—Very strong.
3	44.46	−0.1	222,012	223,404	38.3	38.5	85.0	5,800	−4,771	6.351	1,409,974	17	41	Do.
4	44.34	−0.1	221,060	223,148	38.1	38.5	85.5	5,800	− 256	6.126	1,354,265	19	46	XI—Strong.
5	44.21	−0.1												
6	44.14	−0.1	220,453	223,701	38.0	38.6	87.5	5,800	+ 553	6.150	1,355,772	18	42	VII—Strong.
7	44.06	−0.1	218,437	222,149	37.7	38.3	86.5	5,800	−1,552	6.183	1,350,535	19	47	VIII—Fairly strong.
8	44.04	0.0	219,899	223,727	37.9	38.6	85.0	5,800	+1,578	6.147	1,351,664	18	46	IV—Mild.
9	44.03	0.0	220,211	224,097	38.0	38.6	85.0	5,799	+ 370	5.953	1,310,951	20	47	V—Mild.
10	44.03	0.0	222,411	226,297	38.4	39.0	86.0	5,799	+2,200	6.073	1,350,685	19	50	IV—Mild.
11	44.03	0.0	220,300	224,186	38.0	38.7	86.0	5,799	−2,111	6.268	1,380,929	20	57	V—Mild.
12	44.00	0.0												
13	44.02	0.0	223,000	226,944	38.5	39.1	85.0	5,799	+2,758	6.194	1,381,245	17	52	V—Very little.
Sept. 30	4.73	−0.4	52,610	52,610	31.8	31.8	49.5	1,656	....	2.609	141,982	18	20	

Oct. 1	4.35	—0.4	50,330	50,958	30.6	30.8	47.8	1,647	—1,652	2.553	128,475	19	31	V—Strong.
2	4.02	—0.4	49,470	50,642	30.1	30.6	46.8	1,645	— 316	2.669	132,056	19	26	V—Slight.
3	3.71	—0.4	50,245	51,927	30.6	31.4	47.3	1,643	+1,285	2.497	125,470	19	29	IV—Strong.
4	3.5	—0.2												
5	3.26	—0.2	50,522	52,946	30.8	32.0	47.7	1,642	+1,019	2.641	133,450	17	23	XII—Strong.
6	3.00	—0.3	50,508	53,357	30.8	32.2	47.7	1,638	+ 411	2.509	126,732	19	32	Calm.
7	2.68	—0.3	49,842	53,213	30.5	32.1	47.9	1,633	— 144	2.531	126,132	18	34	XI—Medium.
8	2.46	—0.3	48,678	52,410	29.8	31.6	46.9	1,632	— 803	2.421	117,835	18	33	XII—Slight.
9	2.21	—0.2	48,552	52,694	29.8	31.8	47.1	1,631	+ 284	2.484	120,600	19	31	XII—Strong.
10	2.05	—0.2	48,940	53,339	30.1	32.2	46.8	1,627	+ 645	2.433	119,080	18	33	XII—Mild.
11	1.8	—0.2												
12	1.71	—0.1	48,222	53,175	29.7	32.1	47.3	1,624	— 164	2.248	108,390	17	38	Calm.
13	1.58	—0.1	47,865	53,031	29.5	32.0	46.6	1,624	— 144	2.189	104,800	18	38	VI—Strong.
14	1.46	—0.2	48,232	53,595	29.7	32.4	47.1	1,624	+ 564	2.223	107,200	18	41	XI—Slight.
15	1.37	0.0	48,210	53,722	29.7	32.4	47.1	1,625	+ 127	2.202	106,145	18	39	I—Mild.
16	1.34	0.0	47,858	53,418	29.5	32.3	46.8	1,624	— 304	2.199	105,230	18	40	IV—Medium.
17	1.40	+0.1	47,195	52,658	29.0	31.8	46.4	1,625	— 760	2.291	108,120	18	40	VI—Medium.
18	1.6	+0.2												
19	1.83	+0.2	48,048	52,813	29.5	31.9	46.8	1,630	+ 155	2.429	116,715	18	42	XII—Medium.
20	2.02	+0.2	48,068	52,528	29.5	31.7	47.1	1,632	— 290	2.440	117,280	18	39	VI—Mild.
21	2.23	+0.2	49,000	53,114	30.0	32.1	47.0	1,635	+ 591	2.427	118,908	18	43	VII—Medium.
22	2.41	+0.1	48,808	52,629	29.8	31.8	46.9	1,638	— 485	2.562	125,038	19	40	XI—Strong.
23	2.51	+0.1	49,122	52,781	30.0	31.9	47.1	1,640	+ 152	2.545	125,015	19	41	VII—Mild.
24	2.53	0.0	48,680	52,306	29.7	31.6	46.8	1,640	— 475	2.490	121,212	19	40	VII—Strong.
25	2.4	0.0												
26	2.37	—0.1	48,622	52,510	29.7	31.7	46.6	1,639	+ 204	2.523	122,678	19	38	VI—Mild.
27	2.2	—0.2												
28	1.99	—0.2	48,175	52,634	29.5	31.8	46.7	1,635	+ 174	2.356	113,498	17	36	VI—Slight.
29	1.86	—0.1	47,750	52,470	29.2	31.7	46.7	1,633	— 214	2.412	115,156	18	42	VII—Medium.
30	1.75	—0.1	47,608	52,506	29.2	31.7	46.6	1,631	+ 36	2.252	107,210	19	45	VII—Slight.
31	1.69	—0.1	47,090	52,086	28.9	31.5	45.8	1,631	— 420	2.205	103,850	18	40	VI—Medium.
Nov. 1	1.6	0.0												
2	1.60	0.0	47,652	52,798	29.2	31.9	47.1	1,632	+ 712	2.410	114,852	18	39	I—Mild.
3	1.51	—0.1	47,212	52,506	28.9	31.7	46.2	1,632	— 292	2.297	108,425	18	39	Do.
4	1.39	—0.1	46,655	52,143	28.6	31.5	46.2	1,630	— 363	2.317	108,115	19	41	VI—Mild.
5	1.29	—0.1	46,330	51,980	28.4	31.4	45.8	1,629	— 163	2.323	107,622	18	39	Calm.
6	1.14	—0.1	46,640	52,528	28.7	31.7	45.9	1,624	+ 548	2.287	106,645	18	40	Do.
*7	1.00	—0.1	46,382	52,495	28.6	31.7	45.7	1,622	— 33	2.245	104,130	17	41	VII—Strong.
8	0.9	—0.1												
9	0.93	+0.1	45,502	51,732	28.0	31.2	45.4	1,623	— 763	2.402	109,275	18	42	VI—Strong.
10	1.00	0.0	45,865	51,982	28.2	31.4	45.3	1,624	+ 250	2.322	106,482	18	42	VIII—Medium.
*11	0.97	—0.1	45,828	51,996	28.2	31.4	44.8	1,625	+ 14	2.292	105,042	18	42	VI—Medium.

NOTE.—Velocities measured with double floats. *High Waves.

ROBERTSONVILLE, MISSISSIPPI, CREVASSE.

Apr. 14	44.00	0.0	23,452	....	42.6	....	58.5	550	....	2.615 2.663	61,317 62,452	5 5	31 31	Very light.

ARKANSAS CITY, ARKANSAS.

[Velocity measured with the Price current meter.]

Date.	Gauge.		Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard.	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.								
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1891.	Feet.	Feet.	Square feet.	Square feet.	Feet.	Feet.	Feet.	Feet.	Square feet.	Feet.	Cubic feet.	Cubic feet.	Cubic feet.			
Mar. 6	45.0	+0.2	211,427	200,239	61.7	58.6	86.0	3,427	....	6.044	1,277,796	....	1,277,796		22	X—Very light.
7	45.3	+0.2	209,919	197,773	61.3	57.9	85.0	3,427	−2466	5.980	1,255,313	....	1,255,313		66	II—Brisk.
8	45.6	+0.2	204,461	191,391	59.7	56.0	84.0	3,427	−6382	5.595	1,143,893	....	1,143,893		48	VIII—Strong.
9	45.6	+0.2	206,096	192,718	60.1	56.4	86.0	3,427	+1327	6.057	1,248,259	*2000	1,250,259		66	VII—Brisk.
10	45.8	+0.2	212,411	198,485	62.0	58.1	88.0	3,427	+5767	6.051	1,285,342	*2000	1,287,342		47	III—Strong.
11	46.1	+0.2	211,620	196,736	61.8	57.6	82.5	3,427	−1749	5.713	1,208,895	*3000	1,211,895		52	III—Brisk.
12	46.4	+0.2	220,789	204,947	64.4	60.0	87.0	3,427	+8211	5.223	1,153,239	*3000	1,156,239		61	X—Strong.
13	46.5	+0.3	217,666	201,243	63.5	58.9	87.2	2,427	−3704	5.336	1,161,571	*3000	1,164,571		58	IX—Light.
14	46.6	+0.1	213,053	196,219	62.2	57.4	86.2	3,427	−5024	5.368	1,143,689	*4000	1,147,689		65	X—Light.
15	46.8	+0.2														
16	46.9	0.0	219,621	202,000	64.1	59.1	88.5	3,427	+5781	5.486	1,204,917	*4000	1,208,917		60	IX—Very light.
17	46.9	+0.1	221,028	203,236	64.5	59.5	88.5	3,427	+1236	5.497	1,214,996	*4000	1,218,996		59	VII—Very light.
18	47.0	+0.1	221,570	203,539	64.7	59.6	87.5	3,427	+ 303	5.364	1,188,566	*4000	1,192,566		54	III—Light.
19	47.1	+0.1	217,068	198,592	63.3	58.1	86.0	3,427	−4947	5.332	1,157,327	*4500	1,161,827		55	VII—Strong.
20	47.3	+0.1	219,476	200,555	64.0	58.7	87.2	3,427	+1963	5.361	1,176,657	*5000	1,181,657		50	II—Light.
21	47.3	0.0	223,899	204,704	65.3	59.9	88.2	3,427	+4149	5.402	1,209,468	*5000	1,214,468		34	VIII—Strong.
22	47.4	+0.2	229,542	209,971	67.0	61.5	89.0	3,427	+5267	5.356	1,229,326	*5000	1,234,326	12	53	—— Light.
23	47.5	+0.1	229,265	209,557	66.9	61.3	90.0	3,427	− 414	5.260	1,206,033	*5000	1,211,033		53	IV—Very light.
24	47.6	0.0	228,185	208,272	66.6	61.0	89.8	3,427	−1285	5.468	1,247,731	*5000	1,252,731		48	XII—Light.
25	47.7	+0.1	236,566	216,140	69.0	63.3	92.4	3,427	+7868						52	Calm.
†26	47.7	+0.1	242,767	222,272	70.8	65.1	92.0	3,427	+6132						54	VII-VIII—15-25‡
†27	47.8	+0.1	236,039	215,202	68.9	63.0	90.4	3,427	−7070						61	IX—15
28	47.8	0.0	231,922	211,017	67.7	61.8	88.6	3,427	−4185	5.966	1,383,586	*7000	1,390,586		60	XII—10
29	47.9	+0.1														
30	47.9	0.0	235,715	214,604	68.8	62.8	92.0	3,427	+3587	5.992	1,412,422	*7000	1,419,422		57	III—10
31	48.0	+0.1	238,377	216,856	69.6	63.5	93.0	3,427	+2252	5.943	1,416,730	*7000	1,423,730		59	IX—12
Apr. 1	48.1	0.0	236,286	214,491	68.9	62.8	93.0	3,427	−2365	5.927	1,400,553	*8000	1,408,553		53	II to III—5
2	48.1	+0.1														
3	48.2	+0.1	238,896	216,896	69.7	63.5	93.0	3,427	+2405	5.908	1,411,321	*8000	1,419,321		59	VIII—15
4	48.2	0.0	237,108	214,971	69.2	62.9	92.0	3,427	−1925	5.895	1,397,641	*8000	1,405,641		57	X—7
5	48.2	0.0														
†6	48.2	0.0	239,080	216,977	69.8	63.5	92.0	3,427	+2006	5.851	1,398,930	*8000	1,406,930		61	VIII—10
†7	48.2	0.0	239,826	217,826	70.0	63.8	94.0	3,427	+ 849	5.907	1,416,552	*8000	1,424,552		90	IV—8
†8	48.1	−0.1	235,944	214,149	68.8	62.7	91.0	3,427	−3677	5.891	1,390,007	*8000	1,398,007		47	IV—6
9	48.0	−0.1	233,371	211,952	68.1	62.0	90.0	3,427	−2197	5.998	1,399,643	*7000	1,406,643		48	IV—3 to 8

10	47.9	— 0.1	233,627	212,516	68.2	62.2	92.0	3,427	+ 504	5.806	1,356,322	*7,000	1,363,322		57	III—2.
11	47.8	— 0.1	234,131	213,328	68.3	62.4	93.0	3,427	+ 812	5.707	1,336,160	*6,000	1,342,160		59	I—2.
12	47.7	— 0.1														
†13	47.6	— 0.1	230,807	209,867	67.3	61.4	92.0	3,427	— 3,461	5.600	1,292,501	*5,000	1,297,501		49	III—6.
14	47.5	— 0.1	235,135	215,461	68.6	63.1	92.0	3,427	+ 5,594	5.673	1,333,810	*5,000	1,338,810		80	IV—6.
15	47.4	— 0.1	234,173	214,705	68.3	62.9	91.0	3,427	— 736	5.515	1,298,498	*5,000	1,303,498		53	V—2.
16	47.3	— 0.1	234,804	215,746	68.5	63.2	91.0	3,427	+ 1,041	5.592	1,312,947	*4,000	1,316,947		51	IV—6 to 2.
17	47.3	0.0														
18	47.2	— 0.1	233,424	214,606	68.1	62.8	91.0	3,427	— 1,140	5.519	1,288,339	*4,000	1,292,339		54	III—2.
19	47.2	0.0														
20	47.2	0.0	232,139	213,458	67.7	62.5	91.0	3,427	— 1,148	5.449	1,264,850	*4,000	1,268,850		55	II—8.
21	47.2	0.0	232,256	213,711	67.8	62.6	91.0	3,427	+ 253	5.533	1,285,019	*4,000	1,289,049	12	95	IV—8.
22	47.1	— 0.1	231,213	212,771	67.5	62.3	91.0	3,427	— 940	5.475	1,265,945	*4,000	1,269,945		57	
23	47.1	0.0	231,218	212,845	67.5	62.3	91.0	3,427	+ 74	5.531	1,278,767	*4,000	1,282,767		56	IX—5.
24	47.2	+ 0.1	232,893	214,252	68.0	62.7	91.0	3,427	+ 1,407	5.293	1,232,732	*4,000	1,236,732		58	VIII—3.
25	47.3	+ 0.1	231,175	212,117	67.5	62.1	90.0	3,427	— 2,115	5.293	1,223,614	*4,000	1,227,614		107	XII—5.
26	47.4	+ 0.1														
27	47.5	0.0	226,225	206,586	66.0	60.5	89.0	3,427	— 5,551	5.408	1,223,513	*4,000	1,227,513		87	II—1.
28	47.4	0.0	227,716	208,282	66.4	61.0	90.0	3,427	+ 1,606	5.457	1,242,582	*4,000	1,246,582		97	XI—5.
29	47.3	— 0.1	226,119	206,093	66.0	60.6	89.0	3,427	— 1,289	5.295	1,197,256	*4,000	1,201,256		56	VII—1.
†30	47.1	— 0.1	226,192	207,750	66.0	60.8	89.0	....	+ 757	5.239	1,185,024	*4,000	1,189,024		69	VI—3.
May 1	46.9	— 0.3														
†2	46.5	— 0.4	223,634	207,476	65.3	60.7	89.0	....	— 274	5.288	1,182,894	*3,000	1,185,894		53	V—7.
3	46.2	— 0.3														
†4	45.6	— 0.6	225,717	212,407	65.9	62.2	87.0	3,427	+ 4,931	5.023	1,133,799	*2,000	1,135,799	13	51	X—1 to 25.
5	44.9	— 0.7														
†6	43.9	— 0.9	214,211	206,889	62.5	60.6	87.0	3,427	— 5,518	4.770	1,021,791	*1,000	1,022,791	12	53	XI—12.
7	43.0	— 1.0	210,686	206,276	61.6	60.4	83.0	3,421	— 613	4.679	985,886	....	....	13	75	XI—6.
8	41.7	— 1.3	206,625	206,659	60.5	60.5	82.0	3,416	+ 383	4.535	937,091	....	....	13	60	I—1.
9	40.5	— 1.2	202,409	206,505	59.3	60.5	81.0	3,411	— 151	4.319	874,171	....	....	12	58	V—2.
10	39.2	— 1.3														
11	38.2	— 1.0	193,857	205,830	56.9	60.8	79.0	3,406	— 675	4.218	817,613	....	....	12	63	VII—3 to 6.
12	37.0	— 1.2	189,962	205,909	55.9	60.3	77.0	3,399	+ 79	4.188	795,612	....	....	12	57	XI—5.

AT END OF LEVEE AT AMOS BAYOU, ABOVE ARKANSAS CITY.

Mar. 28	§47.8	....	5,590	....	....	....	14.5	868	....	1.05	5,870	....	....	....	14	
28	....	....	4,784	....	....	....	16.5	462	....	1.05	5,023	....	....	....	8	

The second line contains the results obtained 400 feet below the end of levee and are considered by Assistant J. J. Hoopes to be the most reliable on account of having a narrower section. The mean velocity was taken as four-fifths of the surface velocity as determined by floats.

* Adopted from field computation.
† Rough water.
‡ Velocity in miles per hour.
§ Arkansas City gauge.

WILSON POINT, LOUISIANA.

[Velocities measured with the Price current meter. Discharge over bank adopted from field computation.]

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	No. of velocity stations.	No. of soundings.	Direction and force of wind.
	Lake Providence.	Local.	Rise or fall in the preceding 24 hours.	Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.	Width.								
1891.	Feet.	Feet.	Feet.	Sq. feet.	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Cu. feet.	Cu. feet.	Cubic feet.			
Mar. 27	40.7	44.49	0.0	213,394	203,318	56.3	53.7	86.0	3,788	....	5.697	1,215,679	16,000	1,231,679		89	XII—Light.
28	40.8	44.57	+0.1	217,643	207,264	57.5	54.7	86.0	3,788	+3,946	5.759	1,253,440	19,000	1,272,440		74	III—Very light.
29	40.8	......	0.0														
30	40.8	44.68	0.0	217,502	206,706	57.4	54.6	88.0	3,788	−558	5.830	1,268,000	20,000	1,288,000		71	VIII—Strong.
31	41.0	44.72	+0.2	221,904	210,957	58.6	55.7	88.0	3,788	+4,251	5.401	1,198,436	21,000	1,219,436		79	XII—Brisk.
Apr. 1	41.0	44.76	0.0	223,311	212,212	59.0	56.0	86.0	3,788	+1,255	5.278	1,178,578	22,000	1,200,578		72	III—Light.
2	41.0	44.81	0.0	224,436	213,148	59.2	56.3	86.0	3,788	+936	5.460	1,225,445	22,000	1,247,445		68	XII—Brisk.
3	41.0	44.82	0.0	222,064	210,738	58.6	55.6	86.0	3,788	−2,410	5.647	1,253,904	22,000	1,275,904		82	XII—Brisk.
4	41.0	44.73	0.0	221,828	210,843	58.6	55.7	85.0	3,788	+105	5.465	1,212,182	22,000	1,234,182		84	XII—Brisk.
5	40.9	......	−0.1														
6	40.8	44.65	−0.1	222,883	212,201	58.8	56.0	86.0	3,788	+1,358	5.266	1,173,662	21,000	1,194,662		93	VIII—Strong.
7	40.8	44.62	0.0	224,685	214,016	59.3	56.5	86.0	3,788	+1,915	5.434	1,220,867	20,000	1,240,867		81	VIII—Strong.
8	40.8	44.57	0.0	226,802	216,423	59.9	57.1	84.0	3,788	+2,307	5.109	1,158,659	19,000	1,177,659		86	
9	40.7	......	−0.1														
10	40.7	44.44	0.0	225,323	215,436	59.5	56.9	85.0	3,788	−987	5.261	1,185,444	18,000	1,203,444		85	
11	40.6	44.34	−0.1	228,798	219,290	60.4	57.9	84.5	3,788	+3,854	5.147	1,177,687	17,000	1,194,687		84	
12	40.5	......	−0.1														
13	40.4	44.13	−0.1	224,523	215,811	59.3	57.0	83.5	3,788	−3,479	5.201	1,167,754	17,000	1,184,754	13	84	VIII—Brisk.
14	40.3	44.07	−0.1	221,943	213,458	58.6	56.4	83.0	3,788	−2,353	5.269	1,169,514	16,000	1,185,514		84	VIII—Strong.
15	40.2	44.00	−0.1	224,759	216,539	59.3	57.2	82.0	3,788	+3,081	5.166	1,161,194	16,000	1,177,194		82	VIII—Light.
16	40.1	43.91	−0.1	224,070	216,191	59.2	57.1	82.5	3,788	−348	5.145	1,152,941	15,000	1,167,941		89	VIII—Very light.
17	40.1	43.84	0.0	223,939	216,325	50.1	57.1	82.0	3,788	+134	5.059	1,132,842	15,000	1,147,842		86	VIII—Light.
18	40.1	43.83	0.0	223,381	215,805	59.0	57.0	82.0	3,788	−520	4.895	1,093,441	14,000	1,107,441		81	VIII—Brisk.
19	40.0	......	−0.1														
20	40.0	43.75	0.0	223,153	215,880	58.9	57.0	80.0	3,788	+75	4.915	1,096,789	14,000	1,110,789		76	VIII—Brisk.
21	39.9	43.70	−0.1	224,029	216,945	59.1	57.3	81.0	3,788	+1,065	4.911	1,100,314	13,000	1,113,314		82	VIII—Brisk.
22	39.9	43.69	0.0	227,913	220,897	60.2	58.3	81.0	3,788	+3,952	4.810	1,096,329	13,000	1,109,329		75	XII—Light.
23	39.9	43.69	0.0	230,538	223,492	60.9	59.0	81.5	3,788	+2,595	4.781	1,102,229	13,000	1,115,229		79	XII—Brisk.
24	39.9	43.69	0.0	235,318	228,272	62.1	60.3	81.5	3,788	+4,780	4.618	1,086,707	13,000	1,099,707		76	
25	39.9	43.74	0.0	234,720	227,494	62.0	60.1	81.0	3,788	−778	4.585	1,076,294	14,000	1,090,294		74	XII—Brisk.
26	40.0	......	+0.1														
27	40.0	43.87	0.0	233,859	226,131	61.7	59.7	83.5	3,788	−1,363	4.662	1,090,159	15,000	1,105,159		81	XII—Very light.
28	40.0	43.89	0.0	233,064	225,261	61.5	59.5	83.0	3,788	−870	4.677	1,090,047	15,000	1,105,047		83	II—Strong.
29	40.0	43.84	0.0	231,083	223,469	61.0	59.0	84.0	3,788	−1,792	4.742	1,095,869	15,000	1,110,869		162	VI—Very light.
30	39.9	43.74	−0.1	227,466	220,231	60.0	58.1	83.5	3,788	−3,238	5.086	1,156,801	*12,500	1,169,301		97	V—Brisk.

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May 1	39.8	43.61	— 0.1	224,483	217,740	59.3	57.5	83.0	3,788	—2,491	4.871	1,093,508	10,000	1,103,508		114	
2	39.6	43.42	— 0.2	223,459	217,436	59.0	57.4	83.0	3,788	— 304	5.182	1,157,930	7,000	1,164,930		142	
3	39.4	....	— 0.2	....	....	....	....	....	....	....	....	....	....	....		....	
4	39.1	42.84	— 0.3	221,906	218,080	58.6	57.6	80.0	3,788	+ 644	4.616	1,024,241	7,000	1,031,241		82	
5	38.8	42.46	— 0.3	221,903	219,517	58.6	58.0	80.0	3,788	+1,437	4.994	1,108,242	5,000	1,113,242		77	
6	38.3	....	— 0.5	....	....	....	....	....	....	....	....	....	....	....		....	
7	37.7	41.07	— 0.6	219,827	216,948	58.0	57.3	78.0	3,788	—2,569	4.684	1,029,777	3,000	1,032,777		84	II—Brisk.
Oct. 16	1.6	4.98	— 0.2	68,146	203,499	20.7	53.7	37.5	3,295	....	1.955	133,212	....	....	9	43	VI—Light.
17	1.5	4.84	0.1	68,389	204,227	20.8	53.9	37.5	3,295	+ 728	1.951	133,410	....	....	9	51	V—Light.
20	1.4	4.68	0.0	69,003	205,389	21.0	54.2	38.5	†3,293	+1,158	1.938	133,725	....	....	9	50	VII—Brisk.
Nov. 12	0.8	3.88	0.0	63,507	202,620	19.4	53.5	36.5	3,280	—2,794	1.845	117,142	....	....	9	62	I—Brisk.

LOUISIANA BEND, LOUISIANA.

[Velocities observed with the Price current meter at six-tenths depth.]

Oct. 19	1.8	....	....	67,392	....	42.5	....	77.0	1,585?	....	1.955	131,729	....	....	7	32	I—Brisk.

CONCORD CREVASSE.

[550.5 miles from Cairo; opened March 21 at 8 a.m.; results from reduction at office of third district engineer.]

Apr. 18	40.1	....	0.0	15,650	....	8.1	....	....	1,930	....	6.4	100,192	....	....	....	....	

*Interpolated in Secretary's office. † Interpolated.

NATCHEZ, MISSISSIPPI.

[Velocities measured with the Price current meter.]

Date.	Gauge. Standard.	Gauge. Rise or fall in the preceding 24 hours.	Cross section of discharge. Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.	Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
1891.	Feet.	Feet.	Sq. ft.	Sq. ft.	Feet.	Feet.	Feet.	Feet.	Sq. ft.	Feet.	Cubic feet.	Cubic ft.	Cubic feet.			
Mar. 24	46.10	−0.1	156,111	156,961	73.7	73.5	105.3	2,117		9.208	1,437,441				12	Calm.
25	46.10	0.0	155,820	156,670	73.6	73.4	105.8	2,117	− 291	9.665	1,506,055				12	Do.
26	46.20	+0.1	155,435	156,073	73.3	73.1	107.2	2,121	− 597	8.829	1,372,414				12	Upstream; strong.
27	46.15	0.0	156,407	157,151	73.8	73.6	106.7	2,119	+1,078	8.944	1,398,924				12	Do.
28	46.15	0.0	157,720	158,464	74.4	74.2	111.8	2,119	+1,313	8.833	1,393,145				12	Calm.
29	46.18	0.0	155,879	156,560	73.5	73.3	110.9	2,122	−1,904	8.760	1,365,426				12	Do.
30	46.15	0.0	156,613	157,358	73.8	73.7	111.2	2,123	+ 798	9.739	1,525,255				12	Upstream.
31	46.30	+0.1	158,452	158,878	74.4	74.4	109.4	2,130	+1,520	9.461	1,499,040				12	Down; brisk.
Apr. 1	46.35	+0.1	154,683	155,003	72.6	72.6	116.6	2,130	−3,875	8.934	1,381,895				12	Upstream; strong.
2	46.38	0.0	151,463	151,719	71.1	71.1	109.7	2,130	−3,284	9.634	1,459,220				11	Down; strong.
3	46.38	0.0	148,178	148,434	69.6	69.5	106.2	2,130	−3,285	9.133	1,353,273				11	Upstream; brisk.
4	46.40	0.0	151,082	151,296	70.8	70.9	107.1	2,135	+2,862	9.161	1,384,082			11	11	Calm.
5	46.4	0.0														
6	46.40	0.0	152,931	153,145	71.6	71.7	109.5	2,135	+1,849	8.920	1,365,481				11	Upstream; brisk.
7	46.35	0.0	152,582	152,902	71.5	71.6	115.4	2,135	− 243	8.906	1,358,853				11	Upstream.
8	46.35	0.0	156,634	156,954	73.4	73.5	116.5	2,135	+4,052	9.020	1,412,855				11	Upstream; brisk.
9	46.38	0.0	148,729	148,985	69.7	69.8	118.4	2,135	−7,969	9.017	1,341,122				11	Upstream; strong.
10	46.4	0.0													11	
11	46.50	+0.1	151,145	151,145	70.8	70.8	115.5	2,135	+2,160	8.935	1,350,547				11	Calm.
12	46.5	0.0														
13	46.45	−0.1	145,532	145,639	68.3	68.2	119.0	2,130	−5,506	9.332	1,358,166				12	Do.
14	46.38	0.0	146,993	147,249	69.2	69.0	118.7	2,124	+1,610	8.953	1,316,048				12	Upstream; strong.
15	46.35	0.0	143,342	143,661	67.6	67.3	118.9	2,119	−3,588	9.215	1,320,871				12	Calm.
16	46.80	−0.1	142,869	143,294	67.4	67.1	118.9	2,119	− 367	9.089	1,298,529				*35	Upstream.

*Twelve of these soundings were apparently adopted from the preceding day.

RED RIVER LANDING, LOUISIANA.

[Velocities measured with the Price current meter at six-tenths depth. The discharge over bank is on line of discharge section and partly around the end of an old levee on the right bank. The field notes of this overflow are very incomplete, hence these results are not exact.]

Mar. 10	43.15	+0.2	210,840	232,203	52.8	58.1	81.5	3,991	....	5.132	1,082,080	1,800	1,083,880		
16	44.53	+0.3	209,790	225,646	52.5	56.5	81.1	3,993	−6,557	5.236	1,098,377	1,900	1,100,277		
18	44.82	+0.2	210,145	224,843	52.6	56.3	82.7	3,993	− 803	5.232	1,099,542	2,300	1,101,842		
20	44.98	+0.1	211,710	225,769	53.0	56.5	82.8	3,993	+ 926	5.227	1,106,652	2,300	1,108,952		
24	45.03	0.0	213,541	227,390	53.5	56.9	79.1	3,993	+1,621	5.290	1,120,721	2,700	1,132,421		Upstream; brisk.
27	45.03	0.0	211,000	224,859	52.8	56.3	80.7	3,993	−2,531	5.359	1,130,830	2,800	1,133,630		Downstream; strong.
Apr. 2	45.18	0.0	213,399	226,661	53.4	56.7	84.2	3,994	+1,802	5.325	1,136,289	2,800	1,139,089	21	22
7	45.22	0.0	211,193	224,295	52.9	56.1	79.9	3,994	−2,366	5.340	1,127,733	2,800	1,130,533		Upstream.
10	45.37	+0.2	216,887	229,390	54.3	57.4	82.3	3,994	+5,095	5.144	1,115,620	2,700	1,118,320		
13	45.47	0.0	219,246	231,351	54.9	57.9	82.1	3,995	+1,961	5.118	1,122,002	2,700	1,124,702		
16	45.44	0.0	218,180	230,405	54.6	57.7	82.3	3,995	− 946	5.083	1,108,948	2,700	1,111,648		
20	45.40	0.0	222,687	235,071	55.7	58.8	83.3	3,995	+4,666	4.930	1,097,757	2,700	1,100,457		Upstream—Strong.
Oct. 15	2.10	0.0	54,021	230,246	15.7	57.6	37.7	3,446	−4,825	2.914	157,438	....	....		NE—Gentle.
16	2.00	−0.1	54,452	231,042	15.8	57.8	42.3	3,446	+ 796	2.744	149,443	....	....		South.
17	1.92	0.0	52,432	229,314	15.2	57.4	37.8	3,446	−1,728	2.718	142,507	....	....	16	17 Do.
Nov. 21	1.92	+0.1	53,763	230,601	15.6	57.7	42.0	3,442	+1,287	2.626	141,179	....	....		Do.
22	3.05	+1.3	55,065	227,626	16.0	57.0	44.0	3,445	−2,975	2.778	152,993	....	....		SE.

ATCHAFALAYA RIVER, SIMMESPORT, LOUISIANA.

[Velocities measured with the Price current meter.]

Mar. 9	40.52	+0.1	59,906	52,450	64.5	59.3	99.7	929	....	3.935	235,760	....	....			Calm.
13	41.60	+0.2	59,364	50,929	63.9	57.5	104.9	929	−1,521	4.465	265,083	....	....			Do.
17	42.40	+0.2	60,365	51,245	65.5	57.9	97.7	921?	+ 316	4.518	272,717	....	....			Do.
19	42.63	+0.1	60,067	50,672	64.3	57.3	100.1	934	− 573	4.695	281,995	....	....			Do.
23	42.81	0.0	63,180	53,621	67.6	60.6	103.9	934	+2,949	4.693	296,482	....	....			Do.
25	42.86	0.0	64,323	54,708	68.7	61.8	104.9	936	+1,087	4.680	301,000	....	....			Downstream—Light.
28	42.84	0.0	63,584	53,987	67.9	61.0	105.0	936	− 721	4.612	293,244	....	....			Upstream.
30	43.00	0.0	63,218	53,470	67.5	60.4	106.1	937	− 517	4.698	296,996	....	....	10	10	Upstream—Strong.
Apr. 4	43.00	0.0	64,103	54,350	68.3	61.4	105.4	938	+ 880	4.713	302,113	....	....			Calm.
6	43.03	0.0	64,120	54,340	68.4	61.4	104.5	938	− 10	4.796	307,522	....	....			Upstream—Strong.
9	43.08	0.0	64,452	54,626	68.7	61.7	106.6	938	+ 286	4.694	302,555	....	....			Do.
11	43.20	0.0	63,618	53,683	67.8	60.7	108.0	938	− 943	4.923	313,192	....	....			Calm.
15	43.28	0.0	64,314	54,306	68.6	61.4	105.3	938	+ 623	4.759	306,075	....	....			Upstream.
17	43.29	0.0	63,612	53,595	67.8	60.6	104.8	938	− 702	4.724	300,510	....	....			Do.
27	43.31	0.0	64,407	54,366	68.6	61.4	108.5	939	+ 795	4.907	316,030	....	....			Downstream.
Oct. 16	0.10	−0.2	20,175	20,175	26.8	26.8	39.6	752	....	0.773	15,599	....	....	6	6	Upstream.
22	− 0.55	−0.2	20,629	21,113	28.0	28.1	40.9	738	+ 752	0.812	16,755	....	....	6	6	Downstream—Strong.
Nov. 20	− 1.04	0.0	20,154	21,003	27.3	27.9	38.9	738	− 110	0.578	11,641	....	....	8	8	

CARROLLTON, LOUISIANA.

[Velocities measured with the Price current meter.]

Date.	Gauge.		Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	No. of velocity stations.	No. of soundings.	Direction and force of wind.
	Car-roll-ton.	Rise or fall in the preceding 24 hours.	Area.		Depth.			Width.						
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							
1891.	Feet.	Feet.	Sq. feet.	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Cu. feet.			
Mar. 4	14.40	+ 0.2	169,466	167,422	71.0	70.8	111.0	2,388	....	6.494	1,100,431			Calm.
5	14.40	0.0												
6	14.50	+ 0.1	172,768	170,487	72.3	72.1	114.0	2,388	+3,065	6.633	1,145,967			S.—Light.
7	14.68	+ 0.2												
8	14.95	+ 0.3												
9	14.65	— 0.3	172,458	169,820	72.2	71.8	120.0	2,388	— 667	6.338	1,093,067			N.—Strong.
10	14.90	+ 0.2	171,980	168,748	72.0	71.4	120.0	2,388	—1,072	6.475	1,113,633			
11	15.15	+ 0.2												
12	15.30	+ 0.2	172,963	168,780	72.4	71.4	110.0	2,388	+ 32	6.375	1,102,558			Calm.
13	15.50	+ 0.2	173,613	168,955	72.7	71.4	113.0	2,388	+ 175	6.735	1,169,357			N.—Strong.
14	15.60	+ 0.1	172,778	167,882	72.4	71.0	112.0	2,388	—1,073	6.954	1,201,557			Do.
15	15.70	+ 0.1												
16	16.05	+ 0.4	173,504	167,539	72.7	70.8	115.0	2,388	— 343	6.812	1,181,978			
17	15.90	— 0.2	176,009	170,400	73.7	72.1	115.0	2,388	+2,861	6.892	1,213,011			Calm.
18	15.80	— 0.1	175,707	170,336	73.6	72.0	115.0	2,388	— 64	6.567	1,153,923			Do.
*19	15.65	— 0.2	173,986	168,972	72.9	71.4	109.0	2,388	—1,364	6.754	1,175,084			SW.—Light.
†19	15.65	— 0.2	175,486	170,472	73.5	72.1	113.0	2,388	+1,500	6.568	1,152,665			Calm.
20	15.55	— 0.1	176,050	171,273	73.7	72.4	113.5	2,388	+ 801	6.689	1,177,626	16	16	Do.
21	15.40	— 0.2	176,156	171,736	73.8	72.6	112.5	2,388	+ 463	6.762	1,191,206			
22	15.30	— 0.1												
23	15.30	0.0	176,934	172,751	74.1	73.0	111.0	2,388	+1,015	6.568	1,162,182			E.—Light.
24	15.20	— 0.1	177,517	173,572	74.3	73.4	115.0	2,388	+ 821	6.628	1,176,657			
25	15.22	0.0												
26	15.30	+ 0.1	176,763	172,580	74.0	73.0	114.0	2,388	— 992	6.485	1,146,306			NW.—Strong.
27	15.10	— 0.2	176,300	172,593	73.8	73.0	114.0	2,388	+ 13	6.447	1,136,602			W.—Strong.
28	15.00	— 0.1	175,978	172,508	73.7	72.9	113.0	2,388	— 85	6.504	1,144,623			Calm.
29	14.95	0.0												
30	15.00	0.0	178,618	175,148	74.8	74.1	117.0	2,388	+2,640	6.352	1,134,515			E.—Strong.
31	15.20	+ 0.2	179,298	175,353	75.1	74.1	119.0	2,388	+ 205	6.443	1,155,153			E.—Steady.
Apr. 1	15.15	0.0	179,658	175,832	75.2	74.3	120.0	2,388	+ 479	6.489	1,165,769			
2	15.00	— 0.2	177,302	173,832	74.2	73.5	117.0	2,388	—2,000	6.472	1,147,509			NW.—Strong
3	15.05	0.0	177,788	174,199	74.5	73.7	118.0	2,388	+ 367	6.479	1,151,968			Do.
4	14.75	— 0.3	176,841	173,965	74.1	73.6	119.0	2,388	— 234	6.693	1,183,654			N.—Strong.
5	14.88	+ 0.1												
6	14.80	— 0.1	177,980	174,986	74.5	74.0	118.0	2,388	+1,021	6.560	1,167,613			SE.—Strong.

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....	14.65	− 0.2	176,426	173,788	73.9	73.5	117.0	2,388	−1,198	6.568	1,158,810			S.—Strong.
8........................	14.75	+ 0.1	176,149	173,273	73.8	73.3	117.0	2,388	− 515	6.614	1,165,135			S.—Light.
9........................	14.80	0.0	177,183	174,189	74.2	73.7	118.0	2,388	+ 916	6.856	1,214,823			S.—Strong.
10........................	14.90	+ 0.1	178,840	175,608	74.9	74.3	118.0	2,388	+1,419	6.729	1,203,431			S.—Strong.
11........................	14.90	0.0	178,885	175,653	74.9	74.3	118.0	2,388	+ 45	6.394	1,143,748			S.—Strong.
12........................	14.75	− 0.2	....	....	....	....	....	....	....	....	....			
13........................	14.70	0.0	178,173	175,416	74.6	74.2	115.0	2,388	− 237	6.649	1,184,716			
14........................	14.80	+ 0.1	178,317	175,323	74.7	74.1	119.0	2,388	− 93	6.485	1,156,379			
15........................	14.65	− 0.2	179,026	176,436	75.0	74.6	118.0	2,388	+1,113	6.511	1,165,565			
16........................	14.65	0.0	178,847	176,257	74.9	74.5	118.0	2,388	− 179	6.487	1,160,140			

HENRY CLAY AVENUE.‡

[Velocities measured with the Price current meter.]

Apr. 3........................	15.05	0.0	223,650	220,061	107.0	105.8	180.0	2,091	....	4.864	1,087,850			
4........................	14.75	− 0.3	224,464	221,588	107.3	106.5	180.0	2,091	+1,527	5.119	1,149,053			
6........................	14.80	− 0.1	219,369	216,375	104.9	104.0	175.0	2,091	−5,213	4.883	1,071,096	21	21	
7........................	14.65	− 0.2	218,616	215,978	104.6	103.8	175.0	2,091	− 397	5.059	1,106,044			
8........................	14.75	+ 0.1	217,319	214,443	103.9	103.1	175.0	2,091	−6,535	4.894	1,063,626			
9........................	14.80	0.0	216,044	213,050	103.0	102.4	174.0	2,091	+1,557	5.090	1,099,578	§21	‖21	
10........................	14.90	+ 0.1	216,869	213,637	103.7	102.7	174.0	2,091	+2,637	5.387	1,168,321	21	21	
14........................	14.80	+ 0.1	216,194	213,200	103.4	102.5	174.0	2,091	− 437	4.803	1,038,305	20	20	

*A. m.

†P. m.

‡This discharge section is about 2¼ miles below the regular Carrollton section and about one-fourth mile below the lower end of the Ames crevasse, which occurred March 16, and increased until the estimated discharge was 91,000 cubic feet per second between April 6 and 14. (See Report of Chief of Engineers, 1891, page. 3684.)

§One of these velocities was not observed, but interpolated from the stations on either side.

‖One of these soundings was not observed, but interpolated from the preceding and following days.

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*Slope observations, Mississippi River, Memphis, Tenn.**

Date.	Maximum surface velocity in feet per second.		Slope, sine of inclination.			
	At gauge No. 4.	At gauge No. 1.	Between gauges 1 and 2.	Between gauges 1 and 3.	Between gauges 1 and 4.	Between gauges 2 and 4.
1891.						
Sept. 29	....	....	.0000000	.0000102	....	....
30	....	....	49	133	....	....
Oct. 1	....	....	63	112	....	....
2	3.01	2.30	49	102	.0000100	.0000126
3	....	....	00	102	100	149
5	2.43	1.99	63	122	084	094
6	2.30	1.99	84	122	115	126
8	2.82	1.97	49	112	092	126
9	....	....	00	102	092	137
10	2.74	1.66	21	102	097	103
12	2.43	1.85	—84	041	046	114
13	2.39	1.64	—84	051	046	126
14	3.20	1.72	21	102	100	137
15	2.82	1.78	63	092	100	114
16	3.23	1.85	63	122	107	126
17	3.23	1.87	49	082	100	126
19	....	....	104	092	107	126
21 †	2.68	1.72	49	122	107	137

* Results of reduction at office of second district engineer.
† Oct. 21 the maximum surface velocity at gauge No. 5 was 2.82, and the slope between gauges 1 and 5 was .0000348.
NOTE.—For field report see page 3120.

*Slope observations, Mississippi River, Helena, Ark.**

Date.	Maximum surface velocity in feet per second.			Slope, sine of inclination.		
	At Gauge A.	At U. S. gauge.	At Gauge D.	Between gauges A and D.	Between U. S. gauge and D.	Between gauges C and D.
1891.						
Oct. 1	....	2.941	3.750	....	.0000267	.0000303
2	....	2.941	3.530	....	320	209
3	....	2.912	3.093	....	191	248
5	....	....	....	....	....	....
6	....	2.941	3.530	....	290	282
7	....	3.000	3.704	....	230	169
8	....	3.061	3.333	....	267	238
10	....	3.093	3.425	....	260	201
12	....	3.061	3.333	....	245	199
13	....	....	....	....	336	236
14	3.489	2.987	3.226	.0000336	230	224
15	....	2.857	3.261	....	259	282
16	3.449	2.655	2.728	348	252	270
17	3.449	2.679	2.804	353	275	273
19	....	3.030	3.253	356	283	232
20	3.530	2.884	3.030	339	222	213
21	....	3.125	3.192	....	237	199
22	....	2.941	3.158	360	150	238
23	3.370	2.655	2.970	370	284	213
24	....	....	....	365	276	213
26	3.530	2.830	3.226	365	252	213
28	....	2.728	3.191	....	253	236
29	3.530	2.752	3.030	363	268	224
30	....	2.542	2.912	....	258	213
Nov. 3	....	3.226	3.371	....	143	120
4	3.400	2.728	3.060	356	252	236
5	....	2.800	3.330	....	245	248
6	3.220	2.830	3.090	355	245	224
7	....	2.550	3.000	....	245	213
9	2.860	2.590	3.030	368	245	218
10	....	2.730	3.290	....	268	234
11	2.913	2.400	2.942	381	268	225

* Results of reduction at office of second district engineer.
NOTE.—For field report see page 3120.

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Slope observations, Mississippi River.

RED RIVER LANDING.

Date.	Bank.	Between gauges 2 and 3.	Between gauges 1 and 5.	Between gauges 1 and 3.
1891.				
Mar. 18	Right	.0001006	.0000472	.0000786
20	Left	.0000735	384	565
	Right	.0000909	.0000457	.0000723
24	Left	848	470	665
	Right	.0000968	.0000399	.0000734
27	Left	914	411	671
	Right	.0001119	.0000212	.0000746
Apr. 2	Left	1001	524	770
	Right	.0001055	.0000424	.0000795
10	Left	1107	508	817
	Right	.0001042	.0000421	.0000786
13	Left	968	648	813
	Right	.0001032	.0000450	.0000792
16	Left	1037	629	840
	Right	.0000993	.0000512	.0000795
28	Left	892	764	830

RED RIVER LANDING AND ROWS LANDING.

Apr. 20, 11:15 a. m.	Left	.0000349		
20, 11:30 a. m.	...do	348		
28, 10:15 a. m.	...do	363		
28, 10:30 a. m.	...do	354		

NATCHEZ.

Apr. 11	Left	.0001456		
13	...do	1308		
14	...do	1353		
15	...do	1358		

ATCHAFALAYA RIVER, AT SIMMESPORT, LA.

Mar. 17	Left	.0001032	.0001826	.0001367
	Right			537
19	Left	1430	1402	1418
	Right			542
23	Left	1389	1356	1375
	Right			579
25	Left	1359	1249	1313
	Right			564
28	Left	1329	1407	1362
	Right			583
30	Left	1341	1749	1513
	Right			565
Apr. 4	Left	1519	1321	1435
	Right			603
6	Left	1511	1413	1470
	Right			624
9	Left	1444	1341	1401
	Right			611
11	Left	1619	1413	1532
	Right			642
15	Left	1381	1244	1324
	Right			644
17	Left	1392	1321	1362
	Right			619
27	Left	1545	1275	1431
	Right			600

NOTE.—Middle gauge was at discharge section.

*Slope gauges, 1891.**

RED RIVER LANDING, LA.

Bank.	Distance between gauges 1 and 2.	Distance between gauges 2 and 3.	Distance between gauges 1 and 3.
	Feet.	*Feet.*	*Feet.*
Right	3,906	2,733	6,639
Left	2,747	2,577	5,324

SIMMESPORT, LA.

Left	2,693	1,961	4,654
Right	....	....	9,904

* Distance between gauges at Natchez, Miss., is 3,600 feet; at Red River Landing and Rows Landing it is 36,607 feet.

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Results of final reduction of rating observations with Price current meters.

No. of meter.	Date.	A.	B.	Mean error of observation.	Mean error of A.	Mean error of B.	Number of observations.	Length of base.	Locality.	Remarks.
	1891.							Feet.		
4	May 5	3.9909	0.1565	±0.0398	±0.0320	±0.0374	16	400.00	Near Arkansas City	Running water.
	Apr. 2	4.8500	−0.452	0.2673	0.2131	0.2393	12	400.00	Huntington Loop	Still water.
	Jan. 19	3.7708	0.2026	....	....	....	32	200.00	Greenville	Running water.
	Mar. 28	4.0473	0.145	0.0558	0.0323	0.0398	13	400.00	Huntington	Still water.
	Apr. 14	4.1296	0.125	0.0753	0.0454	0.0500	13	400.00	......do	Do.
5	May 3	3.7040	0.0343	0.0410	0.0109	0.0150	40	200.00	Wilson Point	Running water.
	Oct. 17	3.5882	0.354	0.0458	0.0263	0.0272	18	200.00	Homochitto, Miss	Still water.
	Oct. 23	3.5612	0.399	0.0633	0.0525	0.0441	25	200.00	......do	Do.
	Nov. 13	3.908	0.1264	0.1645	0.0876	0.1818	16	200.00	......do	Do.
	Mar. 17	3.63305	0.3755	0.0848	0.0552	0.0724	12	400.00	Huntington	Do.
	Mar. 19	3.7439	0.2334	0.0422	0.0236	0.0272	21	400.00	......do	Do.
	Mar. 24	3.6551	0.327	0.0686	0.0504	0.0673	13	200.00	......do	Do.
	Apr. 7	3.57505	0.109	0.0224	0.0134	0.0207	10	200.00	Wilson Point	Do.
6	Apr. 12	3.5662	0.114	0.0215	0.0094	0.0130	15	200.00	......do	Do.
	Apr. 18	3.5771	0.096	0.0315	0.0118	0.0181	15	200.00	......do	Do.
	Apr. 27	3.5632	0.110	0.0201	0.0086	0.0125	24	200.00	......do	Running water.
	May 1	3.5697	0.111	0.0209	0.0078	0.0117	18	200.00	......do	Still water.
	May 8	3.7571	0.318	0.0663	0.0405	0.0506	13	220.00	Huntington Loop	Do.
22	Mar. 27	4.0005	0.266	0.0933	0.0322	0.0401	26	200.00	In company canal	Running water.
25	Mar. 20	3.7317	0.578	0.0447	....	....	17	637.70	Centennial Lake	Do.
34*	Sept. 23	4.1379	−0.0416	0.0421	0.0383	0.0223	17	259.12	....	Still water.

* Used for low-water discharges at Elmot and Memphis.

NOTE.—Meter No. 4 was taken apart and cleaned May 4. Meter No. 5 was broken March 12 and repaired by March 27.

ADDENDA.

NOTE.—In Capt. Leach's annual report for 1890 the discharge table for Helena shows: April 3, discharge over bank 37,370 cubic feet per second, Austin crevasse; April 7, discharge over bank 11,205 cubic feet per second, Louisville, New Orleans and Texas Railway.

The body of the report contains the statement that the flood passed Helena "entirely in the channel," and also a table showing discharge "out of channel" 47,000 cubic feet per second.

In reports of operations, second district, March and April, 1890, the following results of measurement made April 3 of crevasse at Austin, Miss. (289 miles below Cairo), which occurred on the night of April 1, are given:

Width	feet..	270
Maximum depth	do...	49
Mean velocity	feet per second..	4
Area	square feet..	9, 350
Discharge	cubic feet per second..	37, 370

It is stated under date of April 30 that the crevasse did not enlarge after the above measurement was made.

The discharge "over bank" Louisville, New Orleans and Texas Railway is apparently included in the 47,000 cubic feet "out of channel" given above; no record of the measurement of this.

Results of discharge observations, Mississippi River, Wilsons Point, La.

[Field notes received at secretary's office, January 11, 1892.]

Date.	Lake Providence gauge reading.	Cross section of discharge. Water area.	Depth. Mean.	Depth. Maximum.	Width.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	No. of velocity stations.	No. of soundings.
1890.	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Cubic feet.*			
Dec. 28	9.3	78, 536	21.5	52.0	3, 650?	3.292	258, 573	VII.—Light.	12	72
29	9.2	78, 897	21.6	52.0	3, 650?	3.336	263, 191	VII.—Very light	12	70
30	9.5	78, 830	21.6	52.0	3, 650?	3.290	259, 361	VII.—L't to st'g.	12	76

NOTE.—Mr. W. P. Richards, assistant engineer, chief of party. Discharge section 100 feet above high-water section of 1890. Velocities measured with Price current meter No. 5, at six-tenths depth. Rating of January 19, 1891, $y = 3.7708\,x + 0.2026$ used.

APPENDIX 4 I.

Memorandum of low waters of 1891 surpassing former records.

River.	Station.	Date.	Gauge reading.
			Feet.
Mississippi	Hastings, Minn	Nov. 21–22, 1891	—0.65
Do	Chester, Ill	Dec. 6–7, 12–13, 1891	0.9
Do	Cottonwood Point	Nov. 7–8, 1891	—0.40
Do	Mhoon Ledge, Miss	Nov. 7–15, 1891	—1.60
Do	Sunflower Ledge, Miss	Nov. 9 and 14, 1891	2.10
Do	St. Joseph, La	Nov. 15–16, 1891	—4.00
Do	Plaquemine, La	Nov. 13, 1891	0.20
Do	Donaldsonville, La	Nov. 6, 1891	1.70
Do	College Point, La	Oct. 21, 1891	0.00
Do	Fort Jackson, La	Nov. 30, 1891	0.50
Atchafalaya	Simmsport, La	Nov. 8, 1891	—1.60
Old	Turnbull Island, La	Nov. 7, 1891	0.10
Red	Garland, Ark	Nov. 20, 1891	2.12
Do	Shreveport, La	Nov. 14, 16. 20, 1891	—1.50
St. Francis	Wittsburg, Ark	Nov. 3 and 7, 1891	—3.52
Wabash	Mount Carmel, Ill	Nov. 7 and 9, 1891	0.40

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APPENDIX 5.

REPORT OF CAPTAIN S. W. ROESSLER, CORPS OF ENGINEERS, ON OPERATIONS IN FIRST AND SECOND DISTRICTS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., May 28, 1892.

SIR: I have the honor to submit the following report of operations in the first and second districts for the period of May 31, 1891, to May 31, 1892.

FIRST DISTRICT.

The district extends from the mouth of the Ohio River to the foot of Island No. 40, a distance of 220 miles.

Columbus, Kentucky, 21 miles below Cairo.—The work of improvement consists of five spur dikes, built in 1889–'90, to protect about 2,200 feet of bank which was threatening to cave. No injury to the dikes has been noted and no further work is required.

Hickman, Kentucky, 36 miles below Cairo.—A continuous revetment about 1,000 feet long was placed in October, 1890. Nothing has been done since. Up to this year's flood no injury had been done, except a slight undermining at the lower end by an eddy. The Commission have directed that additional ballast be placed on the revetment above low water. The stone for this has been stored on the bank and will be distributed over the revetment at the low water next season.

New Madrid, Missouri, 71 miles below Cairo.—The survey ordered by the Commission at its meeting November 6, 1890, was made September and October, 1891, and a report thereon, with an estimate of the cost of protecting the town against a caving bank, has been submitted to the president of the Commission in a separate communication.

Plum Point Reach, 147–186 miles below Cairo.—Under this title works of improvement have been executed at various points over the stretch of river, about 20 miles long, between Daniels Point and Craighead Point, and since the date of the last Annual Report the improvement has been continued by new bank revetments in Fletcher Bend, Ashport Bend, and Osceola Bar, and by considerable repairs to the old works.

Fletcher Bend.—The revetments in place in this bend at the date of last report consisted of two sections, one a continuous revetment about 7,800 feet long protecting the upper portion of the bend, the other an interrupted system of revetment protecting about 5,200 feet of bank in the lower part of the bend. Between the two sections there was an interval of about 4,000 feet of unprotected bank, and, as the caving was very active and rapidly giving the bank line an awkward shape with respect to the protected banks above and below, the closing of this gap was made the first work of the season.

The bank was cleared of its heavy timber in June, and grading was commenced as soon as the stage of river permitted, on August 4.

The grading was slow and difficult, on account of the many deep-seated stumps encountered, and taxed the capacity of two graders to keep ahead of the revetment party. Mat construction was commenced on the 10th, and continued under favorable conditions of river to its completion, on October 14, when the last mat was sunk. The paving was carried up to about 10-foot stage, and then discontinued on account of lack of stone. It was subsequently carried up to an average height of about 18-foot stage, with several points as low as the 15-foot stage. The total length of bank protected was 4,334 linear feet.

The form of protection used consisted of a subaqueous mat 200 feet wide below the zero contour, a connecting mat woven into the subaqueous mat before sinking, to cover the zone from the zero contour to the actual water line, and a shore paving of riprap stone 10 inches thick placed on a 3 to 1 slope.

Considerable repair work has been done on the old revetment in this bend. Two breaks in the shore work, where the material had washed out through the mattress and allowed the mattress to settle, were corrected and the slope restored by crib mats heavily ballasted with stone. A third break below the water line was repaired by a mat 100 by 225 feet, and additional ballast was placed on the shore mattress of all four sections of the interrupted revetment.

Osceola Bar revetment.—The original project of 1890 contemplated building 7,000 feet of revetment, beginning at the lower end of the bar, where the caving was most active, and extending upstream to and above the point where the current from the crossing above set against the bank, and 4,500 feet of revetment was placed that season. During the past season the revetment has been extended upstream 1,000 feet, the further extension of 1,500 feet contemplated in the original project being ren-

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dered unnecessary by the position of the crossing after the flood of 1891, which was over 2,000 feet below its position in 1890.

Grading was commenced September 19, but suspended after 290 feet of bank had been worked, on account of sloughing, which made it impossible to get a proper slope. The mat was then built and sunk, and the hydraulic grading completed afterwards with indifferent success. Much hand-dressing was required to establish a suitable slope for the stone paving. The latter was carried up the slope during the season as stone became available, but at no point has it been carried above the 15-foot stage. The bank here has an elevation of but little over the 20-foot stage.

Ashport Bend revetment.—Provision having been made for the protection of the entire bend, it was hoped by using two revetment plants to construct at least 3,000 feet of this protection, in addition to the other works in the reach, before the close of the working season; but, owing to lack of stone, only one party was put into the field, and this one was withdrawn for the same reason earlier than usual, after building 3,250 linear feet of revetment. The starting point of the revetment was about 3,500 feet below Ashport, down to which point no caving had occurred during the previous year. Clearing timber from bank was commenced October 1, grading October 5, and mattress work on October 23, after the completion of the Fletcher Bend revetment.

The first mat was made 2,150 feet long and sunk in sections as the weaving progressed, the river being low and current slack. The second and last mat, 1,150 feet long, was commenced November 23 and completed December 10, but was not sunk till the arrival of a tow of stone on the 16th. After the completion of the first mat the method heretofore followed of building the river and connecting mats as one connected whole and sinking them together was discontinued, and the river and connecting mats built and sunk separately.

The paving was carried up to an average height of about the 15-foot stage, except along a piece of bank about 500 feet long at the lower end of the revetment. Here there was a natural foot-slope, with an inclination of from 3 to 1 to 2½ to 1, extending from the water line up to about the 13-foot stage, while above this the bank stood vertical. Here the paving was carried up the natural slope to the foot of the bluff bank and no grading was done, the object being to let the river do its own grading during the present high water, after which the paving can be extended up to the proper height. If this experiment is successful the same method might be adopted wherever such a natural foot-slope exists, with a considerable saving in the total cost of the work.

Daniels Point revetment.—It was contemplated to extend this revetment about 500 feet upstream, so as to cover a pocket which had formed at the upper end; also to repair a break in the old revetment about 400 feet below the head of it. Owing to lack of stone it was impossible to do both, and as there had been no material enlargement of the pocket during the previous flood it was thought best to repair the break in the old revetment. This was done by a river mat 200 feet wide and 350 feet long, two connecting mats 56 by 140 feet and 60 by 160 feet, and stone paving above the water line. This fault was caused by the bank material washing out through the mattress by the return flow of water from the permeable strata at low and falling stages of river. In settling, the mattress was ruptured and an eddy action of considerable violence set up in the hole so formed. The correction of this fault at the time the work was done was deemed more urgent than the 500 feet of new work at the upper end, where but little caving had occurred the previous year. At a recent inspection, however, the caving at the latter point appeared to have again become active and threatened to undermine the end of the revetment. In addition to the repairs above noted, additional riprap was placed over the shore mats of the whole 5,000 feet of revetment, on which there was scant ballast.

Dikes in Elmot and Island 30 chutes.—The gaps in these dikes have not widened materially since the last Annual Report. As the standing portions still offer a great obstruction to the flow of water through the chutes, an attempt has been made to save them and to accelerate the deposit behind them by sinking a portion of the heavy drift which has accumulated on the upstream side. A single layer of drift 50 feet wide was sunk along the Elmont Dike and along a part of Island 30 Dike, in February, March, and April, and work then suspended, as the water was not high enough to float a second layer of drift over the sunken layer. The drift was sunk by constructing over it compact mats of brush about 50 feet wide and 100 to 200 feet long as foundation for the stone, and sinking the whole by heavy ballasting. The thickness of the drift, as indicated by the submergence of the mats, varied from 10 to 18 feet.

Owing to the difficulty experienced in maintaining these pile dikes a project has been prepared and approved for the closure of both chutes by building a solid dam of brush and stone across their common tributary, Gold Dust Chute. This work will be done at next low water, and the stone for it will be stored on the banks near the proposed location of the dam during the present high water.

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Other works in Plum Point Reach.—The works in the reach not above referred to, viz: Gold Dust dikes, Upper Osceola Bar revetment, Osceola dikes, Plum Point dikes, Bullerton revetment, and Bullerton dikes, have sustained no new injury since last report, and no repairs have been made.

Surveys and observations.—The routine observations for depths and velocities at the shoal crossings have been continuously taken, except when the survey party was engaged elsewhere. As the results have been published in the monthly report of operations they are omitted from this report. The least depths found at low water were: Gold Dust to Ashport bar, 6½ feet; head of Elmot Towhead to Fletchers, 8 feet; New Haven to Plum Point, 7 feet; Plum Point to Osceola Bar, 8½ feet; Yankee Bar to Petty, 6 feet. The latter, from its position and shape, was the most difficult one to navigate.

A hydrographic survey of the reach was begun during the low water of 1891, but the soundings were not completed till after the rise commenced. The depths on the map are therefore not to be taken as low-water depths. Blue prints of the survey have been distributed to the members of the Commission.

The changes noted in the position of the crossings since the previous survey in 1890 may be inferred from the following changes in the position of the Government lights: Gold Dust Light, 6,000 feet up; new light at foot of Ashport Bar; Fletchers Light, 3,700 feet down; New Haven Light, no change; Plum Point Light, 2,200 feet down; Osecola Bar Light, 5,500 feet down; Petty Light, 3,200 feet down.

From a point opposite the head of the interrupted revetment in Fletcher Bend a second channel has developed, crossing to the foot of Elmot Towhead and rejoining the main channel at the foot of Island 30. This has resulted from the shape taken by the unprotected interval in the revetment of this bend, causing a deflection of the current toward the opposite shore. Lynchs Channel has enlarged and deepened slightly during the year, and the sand bar which has for several years existed along the channel face of Bullerton Towhead has been washed away, indicating a tendency of the channel to follow again the face of this towhead and cross to the main shore through the gap at the foot of Bullerton. Caving has been active along Ashport Bend, at Plum Point below the revetment, Yankee Bar, and Craighead Point. The caving at the upper end of Osceola Bar, which had been very slight for several years, has again assumed an active phase, and the revetment of this end of the bar will probably be necessary to prevent the reopening of Osceola Chute.

For further details of work in Plum Point Reach see report of Assistant Engineer August J. Nolty, herewith transmitted. There is also appended a statement showing in detail the cost of the material and labor entering into the construction of revetment. The average field cost per linear foot of the revetment built last year was $18.14, or about 8 per cent below the estimate. The cost would have been even less if the expensive delays caused by lack of stone could have been avoided.

SECOND DISTRICT.

Memphis Harbor, 230 miles below Cairo.—The works of improvement for the preservation of the harbor, and the impairment of the harbor by a sand bar which had formed at the upper end of the levee, were fully described in the last annual report. Reference was then made to injuries sustained by the Hopefield Bend revetment by the flood of 1891. After the river had fallen two breaks were discovered, one about 2,750 feet long at the head of the 1884 revetment; the other about 600 feet long in the 1887 revetment and just above the repair work of 1890. In both breaks the bank had caved near the low-water line, the caving extending back, at some points, beyond the top of the shore revetment, at other places leaving portions of this in place with large and deep breaks between them and the subaqueous mattresses. To ascertain the condition of the subaqueous work at the breaks a careful examination by a diver and by probing with a steel-shod wooden rod was made.

The mattress was found on all the sections, but with the inshore edge very ragged and broken up. The distance from where the mat was unbroken to the shore line varied from 80 to 140 feet along the upper or larger break, and from 50 to 100 feet along the lower break.

To make the necessary repairs the sum of $90,000 was transferred from Plum Point Reach, which was subsequently increased by $6,000, obtained from the same source.

Work was commenced at low water in the middle of September, and, after a fortnight's interruption by cold weather in January, was completed at the end of that month. The subaqueous mats along the upper break were given the full width of 200 feet in order to insure a good lap over the old mats. Along the lower break the mat was made 120 feet wide. The connecting mats were from 60 to 80 feet wide and were made thicker than usual near the low-water line.

The shore paving was 10 inches thick and was carried up on a 3-to-1 slope to about the two-thirds stage. To make the paving more compact and prevent undermining by waves dashing through it and washing out its foundation, a layer of quarry spalls was spread over it.

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The old revetment below the repair work of 1890 is about 6,500 feet long, and while there were no actual breaks in it, at some places, usually near the low-water line, the work had settled by sloughing of the bank under it, showing often a slope as steep as 1¼ to 1, and the shore mats as a whole from midstage down showed evidence of rapid disintegration from decay and from boats landing against it. The whole of this shore revetment, which had been insufficiently ballasted, was repaired by a paving of stone 6 inches thick from midstage down to the water line. Where the slope, by reason of sloughing, had become too steep to hold the simple paving, the original slope of the graded bank was restored as far as practicable by thick mats of brush heavily ballasted.

The stone used was obtained by contract from quarries at Williford, Ark., about 118 miles from West Memphis, on the line of the Kansas City, Fort Scott and Memphis Railroad, and was delivered one-half on barges at $1.65 per ton of 2,240 pounds, and one-half on the bank at $1.75 per ton of 2,240 pounds. The brush and poles were purchased in open market at $1.02 per cord for brush and $1.50 per cord for poles, loaded on Government barges.

The approximate cost of completed revetment, with river mats 200 feet wide, connecting mats and shore paving 10 inches thick carried to two-thirds stage, was $19.56 per linear foot.

An itemized statement of cost of this work is herewith.

For further details of this work see accompanying report of Assistant Engineer W. M. Rees.

Two more breaks in this revetment have been made by the present flood. The first occurred April 12, and is in the new work of 1891 where the 600-feet break occurred in 1891, and where one of the Lee Line steamers had been moored most of the fall and winter.

The second occurred April 16, and is located just above the Memphis and Little Rock Railroad incline, where the company's wharfboat has been lying for several years. Both breaks occurred directly opposite the boats and are approximately the same length. The first extends inland about 50 feet and the second about 75 feet. No enlargement is reported since first inspection. It will be interesting to investigate the cause of these breaks when the water recedes. At present it is difficult to account for all the breaks which have occurred in this bend except on the theory that the mooring and landing of boats rapidly hastens its disintegration and may even destroy new work.

On June 4 a telegram was received from the president of the Commission announcing the transfer of $15,000 from Plum Point Reach to Memphis Harbor for the purpose of dredging a low-water channel across the sand bar to the Memphis Elevator. As it was important to begin work without delay so as to keep as far ahead as practicable of the falling river, open-market proposals were solicited from all parties known to have dredge plants on the Mississippi River, from one firm in Pittsburg, and one in Mobile. Communications were also sent to several engineer officers who it was thought might have dredges that could be used for the work. Three propositions were received in reply, one from Maj. Ruffner, one from Huse-Loomis Ice and Transportation Company of St. Louis, and one from the Monongahela and Western Dredging Company of Pittsburg. The latter's bid was 26 cents per cubic yard scow measurement, material to be dumped into deep water, and being the most favorable proposal received was accepted. The plant consisted of one Osgood dipper dredge, 80 feet by 23 feet by 8 feet depth of hold, with a dipper of over 2 cubic yards capacity, two dump scows of 80 cubic yards capacity each, and a towboat. The dredge arrived July 15 and after a thorough overhauling and calking of the scows, commenced work on the 27th. The material excavated was a very tenacious deposit of fine silt and sand, and the progress being slow by day work alone, a double crew was put on and the dredge worked day and night. The funds being exhausted, dredging was discontinued September 27, after 55,004.6 cubic yards had been excavated. The channel obtained was about 1,200 feet long, with a center-line depth of over 10 feet below zero of gauge and a minimum width of 62 feet between the 5-foot contours, and was large enough for the boats landing at the elevator which the low water had not laid up. In fact there were besides the local packets which land at the paved levee, only two packets, the *Cherokee* and *Fred Herold*, that continued to run to the port of Memphis and use the dredged channel during the entire low-water season.

The settling of the citizens' dikes, referred to in last annual report, was noticed again after the flood of 1891, the subsidence vertically being about 4 feet. No lateral movement toward the channel has been noted. In other respects the dikes are in good condition. Caving continues slowly along the bluff between the dikes and the bridge.

Helena Harbor, 306 miles below Cairo.—The work of improvement consists of a continuous revetment 600 feet long and five spur dikes, protecting about 3,000 feet of bank at the steamboat landing, and was built in 1889-'90 under a specific appropriation of $75,000 in the river and harbor act of August 11, 1888. The lower

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three dikes were only partially built on account of lack of funds, and to complete them an allotment of $22,500 was provided out of the river and harbor act approved September 19, 1890. No work was done during the season of 1891, as all the plant available was used elsewhere on more important works. During the coming season the stone stored on the bank in the vicinity of the revetment, about 2,000 cubic yards, will be used in reballasting and repairing the existing work as directed by the Commission November 12, 1891. After the flood of 1891 a cave or landslide occurred in the vicinity of the two lower dikes, elevating the cribs near the low-water line and depressing the shore ends.

Some repairs may be needed here, and these will be made with any funds that may not be withdrawn for levee purposes.

Surveys, gauges, and observations.—A survey of Hopefield Bend, with special reference to the breaks in the revetment caused by the flood of 1891, was made in June 1891, and survey of the bend, including the harbor as far down as the bridge, was made in October. Hickman Harbor was also surveyed in October. Blue prints have been furnished the members of the Commission. A survey for the new levee behind Lake Charles (357 L.) has been made, as the caving at the head of the lake and below it in the vicinity of Anderson's Landing and Pushmataha has approached so close to the existing levee that new and extensive loops will be necessary or a new levee behind the lake.

Low-water discharge observations were made at Plum Point, Memphis, and Helena, and a single low-water discharge of the Mississippi and Ohio at Cairo. The results have been reduced and forwarded to the secretary of the Commission. High-water discharges for the present flood have been made at Columbus, Ky., Fulton, Tenn., and Helena, Ark. Observations at Columbus and Fulton were discontinued as soon as the flood wave passed. The observations at Helena have at present writing been temporarily suspended and the party sent, at request of the secretary, to Clarendon, Ark., to take a discharge of the White River. Two assistants have also been sent at the secretary's request to Little Rock to take the discharge of the Arkansas, Capt. Taber having kindly offered the use of one of his boats for this purpose.

An examination and survey of Nonconnah Rock was made in October, 1891, and the results will be reported in a separate communication.

Levees.—The levees in the second district include about 120 miles of Yazoo Delta levee on the left bank, extending from the bluffs below Memphis to a point opposite the mouth of White River, and about 34 miles levee on the White River Front. The latter is divided into two sections, one about 15½ miles long below Helena, and one about 18½ miles in the vicinity of Laconia, with a gap of over 30 miles between them in which there is no levee except the old and badly broken up State levee through which there is a large escape of water from the Mississippi into the White River in times of flood.

The levee contracts in force at the date of last report are indicated in the following table. The contracts were completed in June and July. A full description of the levees is given in the last annual report.

Levee.		Total cubic feet.
Section 60	(309 L.)	52,503
Section 61	(310 L.)	37,568
Section 66–67	(315–316 L.)	98,932
Hushpuckana	(353 L.)	81,037
Robertsonville	(354 L.)	42,060
Apperson Field	(355 L.)	89,147
Laconia Levee	(364–½–385 R.)	505,088

Under new allotments made by the Commission at its meeting of July 15, 1891, the sum of $18,848 became available for continuing levee work in the Yazoo district, and $16,683 for the White River Basin. Under suballotments of the board of district officers on levees in its report of August 28, 1891, these sums, less five per cent retained for high-water purposes, were to be expended at the following localities:

Yazoo Front, $17,906, being 95 per cent of $18,848, to be expended in raising and enlarging the existing levee from Hushpuckana Creek (353½ L.) northward as far as the funds would go.

For the Helena Levee, to be added to the $76,000 already available, $9,500, being 95 per cent of $10,000, and to be expended in extending the levee below Old Town.

For the Laconia system, $6,348, being 95 per cent of $6,683, to be used in extending the Carson Loop northward as far as the funds would go.

The allotment first mentioned was subsequently increased by $5,656.82, taken

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from the balance left over from preceding contracts in the same district, making a total of $23,562.82 for the Yazoo district.

Helena Levee (323-328 R.).—The levee built under the above allotments extends from the end of the Government levee of 1887, which was about 15¼ miles below Helena, to the old levee below Johnson's Hole, closing a large gap in the old levee 28,338 feet long, through which entered the backwater which annually overflowed the lower end of the Helena Basin. The levee crosses in its course Long Lake and Old Town Lake bayous, two deep channels through which the principal inflow took place, and which also provided the natural drainage of the basin at medium and low stages of the river. As it was manifestly dangerous to cut off these outlets until another system of drainage had been provided, the crossing of the bayous was made conditional upon the local board first establishing a new outlet for their drainage. This had not been done up to July 30, and as there had already been considerable delay in getting the right of way, the upper half of the loop as far down as the first bayou was advertised and bids therefor opened August 15, 1891. The lower half of the loop was advertised September 9, a drainage canal having meantime been commenced and well advanced to completion.

The levee was let in four nearly equal sections. Abstracts of proposals are herewith. The price per cubic yard included clearing, grubbing, timber-felling, and all other work incidental to the construction of the levee, and considering the character of the work was almost unprecedently low. For section No. 1, the upper section, the price was 18.96 cents per cubic yard; for section No. 2, 18 cents; section No. 3, 16.94 cents; section No. 4, 18.44 cents. The contractors commenced work promptly after the letting, and having ample forces completed the work in good time before the spring flood. Section No. 1 was completed January 6; No. 2, January 7; No. 3, February 16, and No. 4, March 8. The total length of levee was 28,338 feet. Of this 5,000 feet was enlargement of an old levee and the balance new work. The standard section was 8 feet crown, 1 on 3 side slopes, muck ditch 5 feet deep, and a grade of 3 feet above highest known water (1890).

In places where the soil was not very firm and settling anticipated, the grade was increased to 3½ feet above highest water, and if the levee was over 11 feet high, the land slope flattened to 1 on 3½. The height of the levee across the bayous was about 26 feet, and here the side slopes were 1 on 5. Owing to lack of funds to carry out the standard section the lower 5,000 feet was reduced in grade to 2 feet above high water and a portion of it to a crown width of 6 feet. The total yardage was 445,291 cubic yards.

Below where the new levee joins the old levee the local board have "topped" the old levee to Yellow Banks Bayou, and have built a levee across and beyond the bayou, thus extending the Helena system over 6 miles below its former terminus and furnishing protection from back water to all but those living on the lower border of the district.

Laconia Levee (363 R).—The levee built is an extension upstream of the Carson Loop begun under last year's contract. After some delay in obtaining the right of way bids were opened October 13, after ten days' advertisement, and the contract awarded to Pardesky & Lyman at 16.95 cents per cubic yard. Work was commenced November 16, 1891, and completed February 15, 1892. Total length of levee built, 4,240 feet, containing 50,147 cubic yards. Grade 4 feet above 1890 water, with slopes of 1 on 3 and crown of 8 feet.

Yazoo Front.—The work consisted in enlarging the existing levee above Hushpuckana (352 L) to a height of from 3 to 4 feet above highest water, crown width of 10 feet and land slope of 1 on 3. Bids were opened September 26, after ten days' advertisement, and the contract awarded to T. Sullivan, the lowest bidder, at 15¼ cents per cubic yard. Work was begun early in October, 1891, and completed April 16, 1892. Total contents of muck ditch and enlargement, 72,682 cubic yards.

PLANT.

Under authority from the Chief of Engineers, the plants of the first and second districts have been consolidated as one plant, and only one return is rendered. During the year the rehabilitation of the plant, commenced in 1890, has been continued, work being confined mainly to the steamers and the special plant used in revetment work, the general service being relied on to furnish ordinary decked barges to transport stone and brush. The steamer Titan has been docked, her hull strengthened and painted, and a new and additional set of hog chains put on. The tubular boilers have been taken off and a set of flue boilers substituted. New boilers have been placed also on the *Graham* and *Itasca*. *Grader No. 40* has been docked and repaired. *Grader No. 2* docked and given new gunwales and rakes and minor repairs. Steamer *Abbot* has been docked and painted. Five decked barges, four mattress barges, and two mooring barges have been rebuilt, using the oak bottoms of old district barges which were perfectly sound. The above are the principal repairs.

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In addition, repairs of lesser extent have been made to quarter boats and barges and other plant. A larger pulley has been placed on the sand pump to give the pump a proper speed relative to the engine. For further details of repairs see report of Assistant C. W. Sturtevant, herewith transmitted. During the year 4 barges, 8 mooring barges, 4 quarter boats, and 16 pile-drivers have been lost by condemnation, and one quarterboat by sinking.

The machinery of the pile-drivers has been stored near Elmot, in a warehouse which has been built specially for the purpose at a cost of $2,300.

FLOOD OF 1892, AND HIGH-WATER PROTECTION OF LEVEES.

The flood has not reached a critical height for the levees in the second district the highest stage at Helena, which may be taken as a fair indication of the average height of water against the levees, being 45.8 feet, or 1.9 feet below the flood of 1890. At the lower end of the district and above the mouth of the White River the difference between these floods is less than 1.9 feet, but the exact difference can not now be stated. At one point it is reported that this flood has gone higher than the one of 1890. This is at the lower end of the Helena levee, and is caused by the closure of Long Lake, Old Town, and Yellow Banks bayous, all deep channels, which have heretofore served as high-water outlets from the Mississippi into the Helena Basin, and into White River. At Memphis the highest point reached was 34.6, or 1 foot below the 1890 water.

Upon the approach of the flood a steamer and barge loaded with high-water supplies was stationed at a central point within the district to distribute supplies promptly to threatened points, and an agent of the Government stationed at Helena, Laconia, and at Hushpuckana to supervise any work that might be done by the Government. Guards were placed by the local boards on the lower half of the Helena, at Laconia, and on about 10 miles of levee on the Mississippi side from Hushpuckana to Crews Landing, with the understanding that the Government would supply as far as practicable the material and labor required to make any necessary repairs.

Under this system of coöperation, the weakest levees have been under constant inspection and patrol, and all necessary repairs have been promptly made. The repairs so far made consist in stopping seepage in its various forms, such as sloughing off of the back of the levee due to the saturation of the levee itself, seep holes discharging muddy water, etc., and work of this kind has been done at many points. Nothing has been done to protect against wave wash, as it is believed that injuries from this cause can be repaired at low water for much less than it would cost to prevent them by sacking at high water. A very bad area of seepage having developed behind the high levee at Hushpuckana, a 10-feet levee has been thrown across the creek and about 300 feet behind the main levee to impound a body of water over the area in which the seepage was most dangerous. Besides this one point, which had assumed a dangerous aspect, the levees are all in good condition.

The sums available at the beginning of the flood, which were about $6,000 for the Upper Mississippi levee district and $2,500 for the White River basin, will be nearly exhausted at the end of the flood. Although the work done has been costly, as is always the case at high water, I deem the money expended as applied to good advantage, for the reason that no defects have been corrected that could have been postponed, or that could have been detected and done properly at any other time.

LOW WATER OF 1891.

The river reached an unusually low stage during the months of October and November, with a least gauge reading of + 2.4 at Cairo; + 1.6 at Belmont; + 2.50 at Morrisson; — 0.4 at Cottonwood Point; + 2.7 at Fulton; + 1.00 at Memphis; — 1.6 at Mhoon; + 0.9 at Helena, and — 2.1 at Sunflower. At the beginning of the period blank forms of record for location and depths of shoal crossings were sent to all the pilots with the request that they be filled in and returned at each trip of their boats. Comparatively few of these records were returned, partly on account of the fact that before the lowest stage was reached for which the records were especially desired, all but the local packets, and one weekly packet from Memphis to St. Louis, had laid up. From these and other sources of information the table of shoal crossings, hereto appended, has been compiled.

So much of the table as relates to the river between Cairo and Ashport was deduced from meager data and may not include all the crossings giving 10 feet or less, but for the remainder of the districts from Ashport to White River the table may be regarded as complete. In all there appears to have been 42 crossings, giving less than 10 feet of water. Of these, 35 had less than 9 feet; 26 less than 8 feet; 21 less than 7 feet; 8 less than 6 feet; and a single bar at the head of Island 40 gave 5 feet.

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The latter, besides being the shoalest crossing, was also very crooked and shifting, and was the only one that could not be run at night, even by the local packets making the crossing six times a week. Better water being found in the chute of 40, this channel was cleared of its dangerous snags early in November and thereafter used by all the packets. Besides the Island 40 crossing two others may be mentioned as being specially difficult to navigate. These were Harris Bar, 7 miles below New Madrid, and Peters Towhead, 41 miles below Memphis, both giving 5½ feet of water.

A table of statistics of river commerce, prepared by Mr. A. E. Symmes, chief clerk, is herewith submitted as appendix.

Financial statements to accompany this report will be forwarded as soon as practicable after the close of the month.

Three maps accompany this report, giving the location of the new works of channel improvement and levees built since the date of last annual report in the first and second districts.

Respectfully submitted.

S. W. ROESSLER,
Captain of Engineers.

Gen. C. B. COMSTOCK,
President Mississippi River Commission.

Table of depths at shoal-water crossings, 1891, Cairo to White River, distance 393 miles.

Name of shoal, place, or crossing.	Distance in miles below Cairo.	Depths in 1891.		Name of shoal, place, or crossing.	Distance in miles below Cairo.	Depths in 1891.	
		Feet.	Date.			Feet.	Date.
Wolf Island	26	5½	Oct. 29	Reeves	244	5½	Nov. 2
Medleys	29	6	Nov. 10	Horn Lake	245	5½	Nov. 2
Phillips	54	6	Nov. 11	Cow Island	248	6	Nov. 2
Beckham	77	6	Sept. 27	Horfolk	254	6	Nov. 2
Harris	79	5½	Sept. 28	Commerce	267	9	Nov. 2
Silver Top	84	6	Sept. 28	Blues Point	269	6	Nov. 2
Stewart	89	5½	Oct. 18	Peters Towhead	271	5½	Nov. 2
Atkinson	91	6	Nov. 11	Below Peters	272	9	Nov. 2
Cottonwood Point	123	8	Nov. 11	Ashley Point	274	8½	Nov. 2
O'Donnell	149	5½	Nov. 12	Mhoon	276	6	Nov. 13
Gold Dust	157	6½	Oct. 3	Below Mhoon	277	8	Nov. 2
Fletcher	158	8	Sept. 27	Rosalie	284	9	Nov. 2
Foot of Island 30	163	8	Oct. 1	Hardin Point	288	8	Nov. 11
Plum Point	164	8½	Oct. 1	Harbert	292	9	Nov. 11
Petty	168	6	Oct. 1	Montezuma	312	7½	Sept. 28
Lookout (Island 34)	179	9	Nov. 10	Delta	315	8	Nov. 11
Morgan Point	182	7½	Oct. 9	Friar Point	319	7	Nov. 11
Centennial	203	8	Oct. 7	Islands 67 and 68	362	8	Nov. 11
Head of Island 40	212	5	Oct. 7	Scrub Grass	384	7	Nov. 11
Bradley	215	6½	Sept. 21	Victoria	389	9	Nov. 11
Fort Pickering	232	6½	Nov. 11	Mouth of White River	393.2	......	....
Nonconnah	237	9½	Nov. 11				

APPENDIX 5 A.

REPORT OF ASSISTANT ENGINEER AUG. J. NOLTY ON OPERATIONS AT PLUM POINT REACH.

UNITED STATES ENGINEER OFFICE,
Amelia, Ark., March 31, 1892.

CAPTAIN: I have the honor to sumit the following report on construction at Plum Point Reach for the year beginning June 1, 1891:

The last annual report submitted was for the period ending with May 31, 1891. At that time the following operations were in progress, viz: Unloading stone at Fletchers Bend, putting additional ballast on old work, completing closure of Slough No. 2, Osceola Bar, and slashing timber in Ashport Bend. The latter work, which was done by contract, was completed on the day terminating the last report, at a cost of $115, being at the rate of $5 per acre. Everything over 3 inches in diameter was cut down close to the ground, but nothing removed.

Unloading stone.—This work, begun at Fletchers Bend on the 27th of April, 1891, was continued until the 12th of June, when a delay in the delivery of stone compelled

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a suspension of operations until the 29th, upon which day a tow of stone was received. Work was continued until July 15, upon which day the last barge load on hand was unloaded, and resumed at Daniels Point on the 23d. Information received on the 29th that no more stone need be expected caused a disbandment of the party on the 31st, by which time all but four barge loads of stone, which it was desired to keep afloat, had been unloaded. On August 5 the general service resumed delivery of stone and the work of unloading was resumed the following day. The Huntington and St. Louis Towboat Company also began delivery of stone on the 17th and the work of storing the stone on the bank was continued until the 24th of September, when it was finally stopped, the construction parties then in the field being able to consume the stone as fast as received.

The total amount of stone stored upon the bank was 16,914 cubic yards.

The machine used for unloading stone, and which has been described in my last report, worked well and economically, the only trouble encountered being due to the lightness of the boiler and engine used, which were not designed for such heavy work; hence frequent breakdowns and delays occurred. The minimum cost of unloading was \$0.096 per cubic yard; length of haul, 200 feet; rise, 32 feet; average cost per yard for the whole, \$0.21.

Reballasting old work.—Much of the 1889 and 1890 shore work was but lightly ballasted. This was due to frequent oscillations in the river, which would often submerge a piece of work before the ballasting was completed, in which case only enough stone was thrown on the submerged parts to overcome its buoyancy. Sections B, C, D, and E, Fletchers Bend, and the entire Osceola Bar revetment (1890 work), was thus treated. The Fletchers Bend party began on May 27 and finished June 4. The Osceola Bar party, in addition to reballasting, did the work mentioned below, and finished there on July 28.

Closure of Slough No. 2, Osceola Bar.—Owing to the high stage of the river prevailing at the close of operations in June, 1891, this work could not be completed, and in consequence some damage was sustained by the undermining of one unprotected end of the crib dike and by the erosion of the unprotected bank opposite this end of the crib. The work to be done consisted in putting down a 100-foot floor mat behind the crib dike for the entire width of the slough, restoring the elevation of the sunken crib, and putting in 200 feet of shore revetment on the right bank of the slough.

The progress of this work was interrupted by high water from the 13th of June to the 14th of July. This work, together with the reballasting of the 1890 work, was completed on July 28. No further enlargement of damage need be feared here. All brush and poles used were cut by hired labor. Slough No. 1 is closed at the 12-foot stage and No. 2 at the 8-foot. In order to make the work across the former safe, a floor mat should be placed behind the crib dike to prevent undermining by the overfall.

Revetment, Fletchers Bend, Arkansas.—The initial step toward the completion of this work was taken on June 4, 1891, when a small party that had been reballasting the old work in this bend began clearing the bank from the foot of Section A down. As the bank from 900 feet below the foot of Section A was caving continually, only that part of it where no caving was going on was cleared, the clearing of the rest being postponed until such time as the grading party would have advanced close upon the uncleared portion. The clearing was completed on June 15, and no further work was done here until August 4, when hydraulic grader No. 2 began grading from the foot of Section A downstream. This may be properly called the beginning of the season's active operations.

The grader was started at the foot of Section A to grade around the bank of a pocket, which invariably forms at the foot of a revetment. The bank was nearly semicircular in shape, its radius being about 220 feet. About 90 feet out from the bank the depth of water was 32.5 feet below zero, deepening to 60 feet 200 feet out. The project was to give the grading party one week's start ahead of the weaving party, so as to prevent crowding of one by the other. Good progress was made on the 4th and 5th, 250 linear feet having been graded, when on the night of the 5th, without any apparent cause active caving set in and in a short while not only all the graded portion of the bank had disappeared, but the entire pocket had caved back from 22 feet to 90 feet. It was only through the alertness of the grader crew that damage to the machine by falling timber was averted. The caving ceased as suddenly as it began, but in order to prevent further possible loss of work it was decided to do no more grading here, but to first lay a floor mat and necessary connecting mats. Grading was temporarily suspended, as the river, which was rising, had exceded the 10-foot mark, which had been fixed as the highest stage permissible for grading.

A weaving party was at once organized, and the construction of a foot mat 450 feet long by 200 feet wide begun on the 10th. This mat was sunk on the 15th. On the 11th grading was resumed, but below the pocket. As soon as the foot mat was

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sunk connecting mats to connect the dry bank with the river mat were constructed and ballasted, all brush and stone removed from the disintegrated revetment at the foot of Section A, and the work restored here. The grading and final completion of the bank work in this pocket were postponed for the present, as everything was safe against any further caving. River mat No. 2 was begun on the 20th and sunk on September 2. This mat was 1,150 feet long and, exclusive of shore connections, 200 feet wide, or, with latter included, from 230 feet to 255 feet wide. The method of construction followed for this and all subsequent river mats constructed during the season, except at Ashport Bend, was that laid down in "Details of construction" and its essential features are that the inshore edge of the mat is kept on the zero line by means of guide piles; that from this edge to the dry slope and as far up as desired the shore work is made a part of the river mat, and that by this method of construction the connecting mats are done away with, thus effecting a saving of the material and labor lost by the necessary laps.

It soon became evident that one grader could not keep ahead of the revetment party, hence No. 4 was sent here on the 20th of August and began grading the next day. A small party of self-subsisting laborers had in the meantime been employed in clearing the bank in advance of the grading party. The intention had been to start a second revetment party here, but as the two graders could just about keep ahead of one party this had to be postponed. The cause of the apparently slow progress of the graders was primarily due to the large number of heavy deeply-embedded stumps encountered. Each grader met with from 6 to 10 stumps per day, some as large as 4 feet 5 inches in diameter. The removal of these stumps from the slope was accomplished after grading, by blasting with dynamite, the blasting being usually done after quitting time. River mat No. 3 was begun on the 3d by constructing the head, getting out lines, cables, etc. On the morning of the 5th the plant was swung into position for weaving, and on the 16th this mat, 1,100 feet long, was sunk.

The preliminary work for mat No. 4, such as taking in cables from last mat, building head for the new one, putting out mooring barge and mattress cables, was at once begun by a small party, but as the weaving party had crowded the grading party closely during the construction of mat No. 3, and as the stonework was far behind, the weaving party did not swing into position until the 21st. Mat No. 4, 904 feet long, was sunk on the 30th of September. The preliminary work for mat No. 5 was done by a small party, the bulk of the force being engaged in bringing up the stonework. On October 5 the weaving party swung into position for mat No. 5 the last of the large river mats for this place, which they sunk on the 14th. This mat was 915 feet long. It was constructed in the strongest current found along the bend, and sunk in water whose depth along the outer edge of the mat ranged from 46 feet to 79 feet below zero, the gauge at the time showing a stage of —1.10.

Second District Grader No. 40 having been put in order for work, and not yet being required for duty at Hopefield, was put to work on the 4th of September grading the bank in the pocket and worked there until the morning of the 12th, when it was sent to Hopefield. On September 28, Grader No. 4 having finished here was sent to Osceola Bar. On October 10, all grading having been completed here Grader No. 2 was sent up to Ashport Bend. Further and detailed information about grading will be found under the proper caption.

At the beginning of operations here some trouble and delay was encountered by the frequent oscillations of the river. A rise in the latter part of August compelled a stoppage of grading for five days. From the end of August until the final completion of mat work, in the middle of October, the weather and stage of river was everything that could be desired for rapid, good, and economical work. The difficulties encountered in grading will be more particularly enumerated under the head of "Grading."

The total length of river mat made here, exclusive of repair work, was 4,519 feet linear which is about 175 feet in excess of the length of bank operated upon, the excess being due to the overlapping of the successive mats. Further information regarding mattress construction will be found under the head of "Construction of Mattresses."

After the completion of the mattress work the party were employed in bringing the paving well up above the water line, repairing two small faults, one near the head of section B (1888), and one near the head of the 1888 work in section A. Both of these faults were located in strong eddies caused by projecting points just above, and to these the damage was due. The damage in neither case extending below the zero plane, heavy connecting mats to cover the damaged zone were all that were required, the deep holes being first filled with brush and dirt to restore the slope.

On the 22d and 23d of October the force, having completed all mattress work and having brought the shore paving well above the then prevailing stage of river, was moved to Ashport bend with their plant.

The small party heretofore clearing bank and doing the other work preliminary to

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the active revetment work were transferred to Fletchers Bend, where they began putting additional stone upon the old work, and in addition also began loading stone from the storage piles upon barges for use at Osceola Bar, all stone afloat on barges having by this time been consumed. They continued at these two classes of work until the 25th of November, when the Osceola Bar party having completed their work up to the 13-foot contour was transferred to here and both forces consolidated. The work of shore paving suspended on October 23d was resumed with stone taken from the storage piles. By December 1, all stone heretofore stored on the bank at this place had been expended. On the evening of that a tow of stone was received, but the urgent needs of the Ashport party only permitted the use of a small share of this stone here. After expending this the repair of a new fault, developed near the foot of the 1889 work section A, was begun. This fault in itself was of small magnitude only, but being situated almost at the head of the new work as well as on an exposed point it was deemed advisable to repair it in the very best manner. Hence, a river mat 100 feet wide by 225 feet long was sunk in front, a heavy brush crib built to fill up the hole or pocket, and a connecting mat overlapping the river mat placed over the restored slope, the whole being heavily ballasted. No more stone being available at present the force being employed here was largely reduced. Two more barge loads of stone were received here before the end of the month, with which shore paving was continued. On the 30th of October the party were transferred to Osceola Bar, and no further work was done here until January 15, 1892, when paving was resumed and continued at intervals as stone became available until February 12, when work was finally suspended for the season.

The originally contemplated height of the shore paving was the ⅔ or 20 foot stage, but before much of it had been carried up to that plane the probable deficit in the supply of stone had become so apparent that this height was reduced 2 feet vertically or to the 18 foot stage. The difficulties of delivering stone on the works having been very much increased in January by the closure of the Mississippi River above Cairo by ice, and the approach to quarries on the Ohio being prevented by floating ice, this height was necessarily still further reduced, so that at the close of operations here the paving at some places did not extend above the 15-foot stage. It is believed, however, that the work as it stands now is perfectly safe until a more liberal supply of stone will enable us to complete it as originally projected. At the lower end of the section, or above what before the junction of the new with the 1888 work was section B, the current is very rapid and the water deep. Here the paving for 100 feet has been carried up to the crest of the slope as the current impinges directly against it. It may also be noted that while the slope was being graded here a strong vein of water discharging at the 2-foot contour was encountered. This was during the dry season, and hence it may be assumed that there is a permanent discharge here. As the soil around here was very soft, brush weighted down with stone and clay was embedded in the soft places and the shore mat laid over this. A phenomenon worthy of note occurred here during the rise in November. The inshore end of the head of Mat No. 4 was seen to rise to the surface and immediately a strip about 15 feet long and of nearly the width of the mat (200 feet) was turned over on the mat just like one leaf of a hinge folds back against the other half. This mat was sunk on the 30th of September, going down in fine shape, and I can only account for the above on the assumption that the lower end of Mat No. 3 and consequently also the head of No. 4 rested on some large stumps, of which there are many along the bottom here, and that therefore the first 20 or 25 feet of the mat had assumed a slope steep enough to permit some of the stone ballast to roll further on the mat, thus restoring some of the buoyancy of the head (which by reason of its construction is always the most buoyant part of the mat) until the increased current was able to raise and turn it over. Only one transverse cable was broken, but extra ones were afterward run from the mat to shore. A lot of bailed stone was thrown overboard in such a manner that it would drop on the damaged part, and by preventing any oscillation stop all further damage. It is probable that the piece turned over was not quite as long as the overlap of one mat over the other, for no bare bottom could be discovered with the lead.

Nothing has occurred here since.

The present condition of the new work here is as follows, viz:

	Feet.
Total length of river mat made	4,519
Total length of bank operated upon	4,344
Paving up to 13-foot stage (in pocket)	400
Paving up to 20-foot stage and over	500
Paving up to 18-foot stage	1,000
Paving up to 17-foot stage	175
Paving up to 16-foot stage	1,150
Paving up to 15.5-foot stage	1,119

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Revetment—Ashport Bend, Tennessee.—The starting point for the revetment of this bend was located 3,500 feet below where the prolongation of the Ashport levee would strike the river bank, this being at the time above the locus of active caving.

The initial step was the cutting down of everything above 3 inches in diameter along the timbered bank for a distance of 100 feet back, this work, which was done by contract, costing $5 per acre. It was done in May and more for the purpose of preventing the formation of snags and wrack heaps; 23 acres were thus cleared. Nothing was removed at the time.

On October 1 a small party began the work of clearing the bank preparatory to the commencement of grading, and on the 5th Hydraulic Grader No. 4 began work at the upper end, being followed by No. 2 on the 10th. From the outcrop of the various strata composing the bank it was judged that hydraulic grading would be troublesome and the achievement of a good slope expensive. The bank is composed of layers of blue clay and sand stratified in some places, while other large pockets of sand flanked on either side by projecting points of tough clay were found. At one place the very expensive method of sluicing had to be resorted to. Details of this work will be found under grading.

On October 22 the Fletchers Bend party arrived here and at once began work preliminary to the construction of River Mat No. 1. There being no timber where the anchorage for the mat would come, "dead men" were used for the mooring and shackle lines. On the 24th the plant was swung into position for Mat No. 1, which, on account of the absence of current and the presence of other favorable conditions, was made 2,150 feet long, sections of it being sunk on two occasions before the final sinking. The river, which had, up to then, been at a stage below zero, began rising on November 14, and reports from headwaters indicating a heavy rise with much drift, the part of the mat still afloat was sunk on the 21st.

Mat No. 2, begun on the 23d, length 1,150 feet, was finished on the 10th of December, but, owing to the lack of stone, it could not be sunk until the 16th, by which date a small lot of stone had been received. In the construction of this mat, or rather of the shore work, a change was made. Heretofore the shore work had been joined to the mat so as to practically make a continuous piece of work from the out-stream edge up the dry slope. The line of juncture of the shore and river mat was considered a weak part of the work, as this line necessarily falls upon a part of the bank which, being always submerged, has a steeper slope than the graded portion, hence undue strains are cast upon the junction, tending to rupture or separate the one mat from the other. This was noticed in several cases of previous years' work. Therefore the following method was adopted: Anchor piles, 50 feet apart, were driven along the zero line. Against these the inner edge of the river mat rested, being secured thereto with yokes made out of ⅝-inch wire strand running across the widths of the mat and well fastened to it at every 16 feet. After the mat was sunk these piles were cut off close to the water. Connecting mats were then used to span the zone between the river mat and the dry slopes. The first 450 feet of this mat, being under construction before orders to change the method were received, were constructed in the usual manner.

At the beginning of the work here it was hoped that with two revetment parties about 8,000 feet of work might be accomplished during the season. When the second party had completed the Osceola Bar work on December 13, and were ready to be transferred to here, it was found impracticable to do so, as there was then a lot of work awaiting stone, only a small supply of the latter on hand, and the deliveries from the quarries not at all equal to the demand. The same cause, *i. e.*, limited supply of stone and a large amount of unfinished work, compelled the cessation of mattress construction at this place when Mat No. 2 had been completed. As soon as this mat had been sunk, the force, which had been largely reduced, were employed in construction of the connecting mats and in paving the slope. The progress of this work suffered several interruptions from lack of stone. The force had been reduced by transfers to other works and by discharge, but a certain number of men had to be retained pending the arrival of stone. These men had to be subsisted during the period of no work, and this added considerably to the cost of the work. The original project was to carry all paving up to the 20-foot, or two-third stage, but before much of it had been carried that high it was found necessary to curtail the expenditure of stone by reducing the height of paving to the 18-foot stage. After the graders had completed the slope for Mat No. 2 and before the failure in the stone supply became apparent, they were moved below "Mud Point," which is a sharp point projecting from the bank, whose substrata are composed of a tough blue clay hard to erode. The intention was to run the revetment down close to this point, leave the point from its base outward unprotected, and then resume the revetment below. This, if carried out, would have cut away the point, leaving the bank in good shape for a subsequent connection of the two revetments. It was intended to start the second revetment party here, but, as already indicated above, this plan had to be abandoned. By the time that it became manifest that the supply of stone on hand and prospective

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would not warrant the beginning of any work here, the graders had finished nearly 600 feet of bank, which may be considered so much lost work, as the slope is gradually caving in. The work in this bend, after suffering various delays from lack of stone and from natural causes, was completed for the season on January 20, 1892.

The condition of the work is as follows:

	Linear feet.
Length of revetment	3,250
Paving up to 20-foot stage	300
Paving up to 18-foot stage	2,300
Paving up to 13.5-foot stage	500
Paving up to 16-foot stage	150

The lower 550 feet may be considered as an experimental section, for the natural slope left by the receding water, and which required very little dressing, was taken advantage of and paved up to the foot of the bluff bank, rising from 12 to 15 feet perpendicularly above.

The intention was to distribute a quantity of stone along the top of this perpendicular bank, to be deposited on the slope as it caved in, thus forming a sort of riprap, but the prevailing poverty of stone prevented this being carried out.

It is to be regretted that a more vigorous prosecution of the work at this place was prevented by the scarcity of stone, for up to the latter part of December the stage of river and condition of weather were all that could be desired. Labor, too, was plentiful, and plant sufficient to work two revetment parties to their utmost capacity was on hand.

Caving is now quite active below Mud Point as well as immediately below the revetment, and an early resumption of work and completion of it during the coming season is strongly urged.

The work, as far far as finished, does not extend far enough downstream to have much effect on the sand bar opposite, whose most advanced point lies below Mud Point, but it may prevent its further growth.

Clearing of another strip along the timbered bank will no doubt become necessary shortly if the present rate of caving continues.

Daniels Point.—The work contemplated here called for an extension 500 feet upsteam of the revetment and the repair of a fault in the 1889 work about 400 feet below the head of it. Owing to the limited supply of stone, the former project had to be abandoned after the bank had been cleared and graded. The repairs were finished and consisted in a standard river mat 200 feet wide by 350 feet, long, two connecting mats 56 by 140 feet and 60 by 161 feet, respectively, to connect the river mat with the shore work or paving, a shore mat 36 by 140 feet, and a strip of paving 12 by 135 feet. Neither the shore work nor the paving were carried higher up than the two-thirds stage, the balance of the bank being left as found. Work was begun on December 3, 1891, and completed on January 9, 1892. Four days, from the 5th to 9th, were lost by reason of no stone being on hand to complete the work.

Osceola Bar.—The project for this place was the extension upstream of the 1890 work 1,000 feet, putting a brush sill across Slough No. 2, and putting additional ballast on the 1890 work whenever the declining river exposed sparsely ballasted work. Work was begun on September 19, 1891. A sill mat 80 by 60 by 2 feet was constructed and sunk, which completed the closure of the slough; 2,076 by 355 feet of revetment was reballasted. While this work was going on a part of the force were clearing the bank, which was covered with willows, but no timber, preparatory to grading, and putting in dead men for the anchorages. Hydraulic Grader No. 4 began grading on the 28th. From the very beginning the bank sloughed and caved off badly, requiring a large amount of filling up and hand-dressing in order to obtain a fair slope. Various modifications in the use of the jet were tried, with a view of overcoming this difficulty, but as the bank was composed almost entirely of fine silt, quicksand, and in some cases beds of ooze, without success. Finally, after 290 linear feet had been graded, under great difficulties and expense, grading was discontinued, and as the cost and slow progress of sluicing made this method of grading prohibitory, it was decided to sink the river mat first and then resume hydraulic grading.

The mat party swung into position on the 6th of October and sank the mat on the 26th. It was 200 feet wide, by 1,037 feet long on the outer edge and 987 feet measured on the inner edge, the difference in length being caused by the convexity of the shore. This mat ran well down below the head of the 1890 work, which, as usual, had suffered some slight disentegration from the erosion above.

For 290 feet, where the bank was already graded, the shore work was connected directly to the river mat.

Grading was resumed as soon as the river mat had been sunk, and connecting mats and shore work were placed in position whenever a sufficiently long piece of bank was graded. Grading did not work well at all, even after the mat was sunk, but by means of a large amount of manual labor a good slope was obtained. Owing

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to the oozy nature of the material near the foot of the slope, shore work was laid as a foundation for the paving, the shore work being carried up to firm bottom; 50 feet of the above water part of the 1890 work which was badly undermined and broken up was cut away, the slope restored, and a good junction of the old and new work effected.

All brush work was completed here on November 14, but the completion of the paving up to the 13-foot stage was delayed for want of stone until the 25th, when the party were transferred to Fletchers Bend. No further work was done here until December 30, when, anticipating the arrival of stone, a small party were sent down with instructions to carry up the paving to the 20-foot stage as soon as the stone was received. Information received the following day, however, destroyed these hopes and the party were therefore disbanded. No further work was done here until January 20, 1892, by which time one barge containing 396 cubic yards of stone could be spared from the work and used in raising the paving a little higher. This work, for which a small party was sent here on the above date, was completed on the 23d, and no further work has been done since. One condemned mooring and one mattress barge were sunk in Slough No. 2 behind the crib, and two condemned mooring barges were sunk at the head of Bullerton Tow-Head.

Elmot Chute Dike.—A large field of drift, the accumulation of the past two years, having massed in front of this dike, and the retention of this drift being very desirable as a means to the permanent closure of this chute, and faith in the ability of the dike to hold it long enough to accomplish this result having been considerably weakened by two breaks occurring shortly after its completion, it was decided to sink the drift and thus form a barrier independent of the pile dike. The plan adoptd for this work was to sink a zone of drift about 50 feet wide for the entire length of dike.

Heavy mattresses 50 feet wide by 100 long, distant from the front or upstream row of dike from 10 to 50 feet, were built over the drift and sunk. The length was subsequently increased to 200 feet and more. The mat could be made continuous if desired, in which case frequent detours, to avoid places where the drift is piled up much above the general elevation of the field, will be necessary. For the same reason no regular alignment of the mats is followed, but the most feasible site is followed, care being taken not to get too far away from the dike and to have a close juncture at the ends of the successive mats. As soon as a mat is finished it is heavily ballasted and stone is dumped upon it as long as it continues to sink. The thickness of the drift, as indicated by the submergence of the mats, is from 10 to 18 feet. As soon as enough drift moves over these sunken mats to warrant doing this, a second set will be constructed over the first. The nearest approach to the work is from the dike; hence the barges containing the material are brought up to it, planks laid over or under it, and the material carried or wheeled to the work. When the mats begin to sink a movable raft is used to wheel over and follow up the sinking mat. The mats, having to bear heavy loads, are made of two layers of brush, one at right angles to the other. Lying in a heavy bottom grillage of 8-foot squares and finished with a similar top grillage forming pockets for the stone, they are well tied and wired together, both transversely and longitudinally. This work began on the 22d of February and is now in progress.

Similar treatment is contemplated for Island No. 30 Dike.

Unloading stone.—The first installment of stone for the season of 1892 having been received on March 3, the work of unloading it was begun in Ashport Bend and is now in progress. The machine used last season for unloading being found too light for the work, unloading is for the present done by wheeling out.

DETAILS OF CONSTRUCTION.

Construction of mattresses.—All river mattresses, except a short one laid to cover a fault in Section A, Fletchers Bend, were 200 feet wide, exclusive of shore connections. Their length varied from 350 to 2,150 feet. They were constructed as described in Appendix D 2, Report of the Chief of Engineers, 1891. At Osceola Bar, as already stated, owing to the difficulties encountered in grading in advance of mattress construction, and for the last 650 feet of the Ashport revetment, connecting mats to bridge the space between the river mat and shore work were used. In all other cases, except repairs to existing works, the shore work was joined to the mat, both classes of work being carried on simultaneously. Whenever the stage of river was above the zero line piles were driven every 100 feet so as to hold the inshore edge of the mat on or close to this line. Steel-wire cables were used for anchorage of the mooring barge and the mattress, and when well taken care of will last with unimpaired strength for years.

Though at first looked upon with disfavor by the foreman and like all innovations severely criticised, these sentiments soon changed when it was seen that when once stretched taut the cables require no attention while in use. The height above the

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prevailing stage to which the shore work was carried up the slope was usually about 5 feet vertically, except during a rising river, in which case it was carried higher, as the paving could never be economically done till the river mat was sunk and the stone barges were brought close to the bank. In all cases where the slope was soft from seepage the brush work was carried to firmer soil. The overlap of the successive mats was 25 feet. Shore and connecting mats were constructed in the manner described in the paper mentioned above.

Paving.—Paving was made 10 inches thick, the stone being placed on edge with an inclination toward the water, the angle with the slope being less or greater as the stone was large or smaller. Stone was laid as close as possible and the interstices filled up with quarry refuse when this could be obtained. As very little of this could be had, men went over the paving with sledges breaking off all the projecting points of the stones and with the pieces thus obtained filled in the interstices. When gravel and spall can be obtained it will make a better and cheaper job. This stuff is spread in a thin layer over the paving, and, if some cheap cement grout could be pumped over it, it would make an almost impervious piece of work.

Grading.—Hydraulic grading, on the whole has been very unsatisfactory the past season. This may be accounted for in part by the composition of the soil forming the banks and partly by the many stumps encountered. These latter require the expenditure of a large amount of water to put them in shape for final removal by blasting. Some of these stumps have a penetration of 15 feet and terminate in a network of roots. Both at Fletchers Bend and Ashport Bend from 6 to 10 stumps per day, some as much as 4½ feet in diameter, were encountered by each grader. This not only causes damage to the slope by the excessive quantity of water that has to be used, but greatly retards the progress of grading. Another cause of the unsatisfactory results of hydraulic grading is steepness of the slope, 1 on 3, adopted for the past two seasons' work. As long as slopes of 1 on 4 were used much better results were obtained.

As already stated, at Osceola Bar, after various expedients were tried to obtain a good slope, grading was finally postponed until the river mat was sunk, and even then the work was not satisfactory. At Ashport Bend much difficulty was encountered from the beginning, but for the first 2,000 feet a fairly good slope was obtained. Beyond this distance the difficulties increased, until finally sluicing was resorted to. The excessive cost and slow progress of this latter method precluded its extensive use, and hence where an examination of the bank shows that hydraulic grading will be unsatisfactory it would be advisable, as it certainly would be economical, to construct the mattress before grading, this, of course, to be done where it appears certain that no good slope can be obtained by grading before mattress construction. There is no uniformity in the material composing the banks; loam, clay, silt, and sand are encountered, sometimes in layers one above the other, sometimes pockets of but one material. The worst places are those where the hard material crops out at the water line and then disappears, to be followed by a pocket of sand or silt. The latter material will cave in and wash out, while at the outcrop of the tougher material there will be a good slope with a projecting point.

The holes will have to be filled up with loose material, which hardly ever is given time to settle before the work is placed upon it. When a brush foundation is used the subsequent settlement at these places is not liable to damage the work much, but where the paving rests directly on the slope it will form depressions that increase in extent with each heavy rainfall.

At Ashport Bend, where to complete the project nearly 13,000 feet of work is still required, the bank is such a one the composition of which has just been described, and no doubt some places will be found where grading will have to be deferred until the mattress is down.

Our grading plant I believe to be too large for the work. During the past season three and four 1¼-inch jets were worked from each grader, and the pumps could easily supply six; but as each grader has to work on only one face, there is but little economy in increasing the number of jets beyond three. Besides, the greater the number of jets working on one face the greater the volume of discharge down the slope, and consequent damage. Grader No. 4, whose pumps can be worked independently, has given as great a nozzle-pressure with one pump as with both for the same number of jets, while the fuel consumption was much less in the former case. For each grader to work two faces would require long hose and frequent shifting; then the personnel would have to be increased by four hosemen, and whether the two parties were working toward or following each other they could in neither case avoid deluging each other with water and mud.

The grading plant is insufficient for rapid prosecution of the work. For obvious reasons, it is not practicable to start the grading far in advance of the revetment parties. The daily progress of one grader under favorable conditions is 100 linear feet and may fall as low as 60. The daily advance of the mattress work is 140 feet, and thus it will be seen that when two mattress parties are in the field, each depending on one grader only, they will soon crowd upon the latter. Some of the pump and

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power plant now on hand here might be profitably utilized in the construction of additional and much smaller graders. Much trouble has been experienced with the valve gear on the Davidson pump by excessive friction and consequent cutting of the pin and cam. Attempts to lubricate these parts have been but partially successful. An oil pump applied to the steam chest so as to deliver oil upon the pin has given the best results, but as this has to be operated by the engineer its success depends upon the attention given it by the attendant. During the progress of grading some experiments to determine the relative loss by friction of 3-inch and 4-inch hose were made and the results are transmitted as a separate appendix.

Stone supply.—As mentioned previously, delivery of stone by the general service began on the 27th of April, 1891, and continued, with interruptions, until the 11th of September. On September 14 the first installment on the contract with the Huntingdon and St. Louis Towboat Company was received. Stone was also received from Clarkson & Co., delivered on our barges at the quarry, the towing being done by the district steamer *Titan*. Toward the latter part of the season low water greatly retarded the deliveries of stone, and finally ice in the river stopped it entirely. This not only caused serious delay in the prosecution of work in hand, but prevented the extension of the work, and this at a time when the stage of river was most favorable for the achievement of first-class work. Stone is now being delivered for the coming season's work and stored on the protected banks.

Brush and poles.—The supply of this material has always been adequate. Messrs. Hunter & Frey, of Memphis, Tenn., the contractors, have shown considerable energy in keeping pace with the demands upon them, and their dealings with the work have been characterized by fairness and honesty.

Condition of works—revetment.—All revetment on this reach is in good condition, except that at Daniels Point, which has suffered some damage at its head, caused by the caving of the unprotected bank immediately above, and that at Plum Point, which has suffered damage from a similar cause at its foot. The head of the former work is exposed to great strains, it being situated at the foot of a caving bank, whose recession has left the work exposed to the direct attack of a strong current, and is being undermined and broken up. An early extension of this work about 1,000 feet upstream is necessary for the salvation of a great part of the existing work. Some of the old work should be taken off and the point well rounded, so as not to leave it as salient as it now is. Ashport Bend work is in first-class condition: so is also the more recent work in Fletchers Bend down to Section D. The latter section has suffered slight damage to its lower end, and Section E to both head and foot. The damage to D and head of E is caused by the caving of the 500 feet of unprotected bank between the two and that at the foot by the eddy usually found at the lower end of a revetment.

The work done prior to 1885, here as well as at other localities, shows signs of aging, these signs being the gradual decay of the brush composing the shore work and consequent exposure of the bank. The work of putting additional stone upon all the old work wherever this is scanty should be resumed as soon as possible, and will prolong its life at a comparatively moderate expenditure. Fletchers Bend revetment may be divided into three sections. Section No. 1, the farthest upstream, was constructed in the years 1884, 1888, and 1889. This covers 5,692 linear feet of bank. Section No. 3 is the "interrupted revetment" built in 1888 and 1889, and covers, with the 1,200 of unprotected bank, 5,435 linear feet. The middle section, constructed in 1891, covers 4,344 feet of bank. During the period between the construction of the upper and lower sections and the final completion of the whole revetment the unprotected middle section receded considerably, and this now leaves what was formerly the head of Section B in a very salient position with a strong eddy below it. All sharp projections in a revetment are weak points and usually the first to suffer injury. The danger here is increased by a combination of strong current and eddy and steep under-water slope, the depth 175 feet from zero line being 79 feet below low water.

The Osceola Bar work of 1890 and 1891 is in excellent condition. Bullerton Tow-Head revetment and the 1883 and 1884 work at Osceola Bar are in fair condition, but as already intimated show signs of aging.

Elmot Chute and Island No. 30 dikes suffered some enlargement of the breaks during the early summer of the past year, but the gaps seem now to have attained their maximum width. All other dike work on the reach remains practically as reported last year.

The following suggestions are respectfully offered:

Grading should follow, not precede, mattress construction. My reasons for offering this are that by so doing the difficulties of grading in troublesome soil will be greatly reduced, if not entirely eliminated, and mattress construction can proceed rapidly, not being dependent upon the capacity of the grading plant. Even should it at the end of the working season be impossible to complete the above-water part of the revetment, I believe that that part having only the river mat to protect it

would be entirely safe for at least one season. The transverse cables would of course have to be readjusted after the slope was graded, but this would be a small matter, and when anchor piles are used no transverse cables would be required.

A return to the 1 on 4 slope is strongly urged as a means of insuring the longevity of the work. It is true that this would somewhat increase the first cost of the work, but I believe that this would be more than offset by the increased stability and decreased cost of maintenance.

The brush shore work should run up to at least the 10-foot stage, in order to insure a good foundation for the stone. The lower third of the slope is usually found very soft, and if the paving is laid direct on this material unequal settlement is certain to take place.

Upper Osceola Bar should be revetted along its outside bank. Caving has been going on here for years, until now the distance from the river to the chute is only 580 feet. Should the river break through here the greatly weakened closure works would be unable to withstand the increased volume of water, and serious results might follow. About 2,000 feet of revetment and a sill across a small slough would secure the threatened locality and possibly be all that would be required under existing conditions. The continuation of Section D, Fletchers Bend revetment, down to the head of Section E appears, in my estimation, to be necessary, in order to prevent further damage to both pieces of work. The damage, though not serious as yet, is liable to increase rapidly with the further recession of the unprotected bank.

Respectfully submitted.

AUG. J. NOLTY,
Assistant Engineer

Capt. S. W. ROESSLER,
Corps of Engineers, U. S. A.

APPENDIX 5 B.

REPORT OF ASSISTANT ENGINEER W. M. REES, ON OPERATIONS IN HOPEFIELD BEND, ARKANSAS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., March 2, 1892.

CAPTAIN: I have the honor to submit my report on improving Mississippi River at Hopefield Bend, Ark., during the season of 1891–'92.

The work covered by the project embraced repairs to the breaks in the revetment, made during the flood of 1891, and a general strengthening of the remaining work.

There were two large breaks, one at the head of the 1884 revetment, which was 2,750 feet long, and the other along the 1887 revetment, immediately above the repair work of 1890, and which was 600 feet long, the total length of the breaks being 3,350 feet. The banks had caved near the water line, extending inland at some points beyond the top of the shore revetment; at other places leaving portions of this in place, with large and deep breaks between them and the subaqueous mattresses. To determine how far the latter had been broken, a diver was employed, who made examinations on sections located at each 100 feet along the bank. The mattress was found on all the sections, sometimes by the diver, but more frequently by means of probing with a long wooden pole, shod with a steel point, which was pushed through the deposit covering the mattress in many places.

The distance from the shore line, at low water, to where the mat was found unbroken, was from 80 to 140 feet along the upper break, and from 50 to 100 feet along the lower.

The plan then formed was to make the mattresses 200 feet wide along the former and 120 feet wide along the latter, insuring large laps in all cases; to connect these with the upper bank by connecting mattresses, made much thicker than usual at the low-water line, and above these to pave the bank with 10 inches of stone to about the two-thirds stage.

Below the breaks there was about 6,500 feet of revetted bank, and whilst there were no breaks in this work, at some places, usually near the low-water line, the work had settled from sloughing off the bank under it, showing often a grade as steep as 1½ on 1. These places were to be strengthened by placing along them shore mattresses, sufficiently cribbed up, and the entire work, which had been insufficiently ballasted, to be paved to about mid-stage.

The river being sufficiently low, work was begun in the middle of September, 1891, and continued throughout a very favorable season until near its close, January 9, 1892, when a severe snowstorm and subsequent cold weather caused suspension until January 23, after which a week's work finished the project.

The work was done by hired labor, brush and poles being supplied by contract

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and delivered on Government barges about 23 miles above Memphis, Tenn. The stone was also furnished by contract from quarries at Williford, Ark., about 118 miles from West Memphis, on the line of the Kansas City, Fort Scott and Memphis Railroad, and delivered, one half along the bank over a railroad track paralleling it and built by the contractor, and the other half on Government barges at West Memphis, Ark.

Grading.—As the caving had not displaced all the old revetment, this had to be removed preparatory to grading. The bank also was covered with heavy timber, which was felled and cleared back for a distance of about 100 feet. Hydraulic grading was begun on September 15, 1891, and finished on November 19, and as the stage of the river was very favorable, being near low water during the entire time, a very satisfactory grade was obtained, in no case being greater than 33⅓ per cent, the average being about 30 per cent.

The total length of graded bank was 3,475 feet; quantity of material removed, 82,584. This cost $0.045 per cubic yard for pump work, but, adding to this the cost of clearing and trimming the bank, the cost reaches $0.067 per cubic yard.

Three grading machines were used; on one the pumps were duplex condensing, with 20-inch steam cylinders, 10-inch plungers, and 12-inch stroke. These delivered two streams, removed an average of 67.4 cubic yards per hour, at a cost of 0.043 per cubic yard. They were worked at high pressure as the condenser was out of order, otherwise the cost would have been less. The other machines had compound, non-condensing duplex pumps, with 16½ and 10 inch steam cylinders, 6½-inch plungers, and 10-inch stroke: they delivered but one stream and graded each 48.5 cubic yards per hour, at a cost of $0.047 per cubic yard.

All the pumps worked under a pump pressure of 160 pounds per inch and used 3-inch hose and ⅞-inch nozzles.

Subaqueous or river mattresses.—These were of the usual type of woven mattresses, strongly built and cabled. They were sunk after the bank was graded, the shore edge being in all cases at or below the extreme low-water line. The length of bank covered was 2,588 feet.

Four mattresses were sunk of the following dimensions: No. 1, 613 by 120 feet; No. 2, 715 by 200 feet; No. 3, 440 by 220 feet, and 320 feet by 200 feet; No. 4, 550 by 220 feet. The cost per square foot in place was $0.0351.

Connecting mattresses.—These well overlapped the river mattresses and extended up the graded slope until a good foundation was reached whereon to begin the paving. They therefore have their shore edges at different levels, some near low water and others at mid-stage, and vary in width from 30 to 80 feet.

They were all built on ways and similar to the river mattresses, but after being launched received one or more layers of small brush, and where steep places occurred in the slopes below the water line they were cribbed to bring their tops to a uniform grade when sunk. They vary in thickness from 1½ to 4 feet. They were sunk along the entire graded bank, along 1,735 feet of the old work of 1887-'88 and 420 feet of the work of 1885, the total length of bank they covered being 5,725 feet; average width, 66.3 feet; area, 379,965 square feet, and cost $0.0559 per square foot.

The quantity of brush and poles used in the river mats was 0.77 cords per square of 100 feet, and in the connecting mats 1.40 cords per square: the stone used in ballasting was for the river mats 0.71 tons per square, and for the connecting mats 1.27 tons per square.

Paving.—Preparatory to paving the grade was neatly dressed, and when the materials were hard clays or buckshot soil, the stone was placed directly on them, but when soft materials or sand were encountered they were covered either by extending the connecting mattresses or with detached layers of small brush as a foundation. The stone used was in pieces weighing from 10 to 40 pounds, laid as close as practicable, the interstices filled with small stones, and the top covered with a layer of small broken stone or spalls. Care was thus taken to stop all large holes, for it was discovered that large openings permitted the wave wash to pass in and undermine the paving, whilst when the openings were small the interstices were quickly filled with sediment. When the paving was placed on a brush foundation no spalls were used.

The total pavement laid was 500,843 square feet. Of this 275,118 square feet was laid along the graded bank, 210,118 square feet being directly on the earth, and having no subfoundation. This portion reaches to the 22-foot stage, the average width above low water being 76 feet.

Two hundred and seventeen thousand three hundred and twenty-five square feet was laid on the old work of 1887-'88, covering the bank from low-water to near the mid-stage; 8,400 square feet was also laid in the pocket of the 1885 work.

The average thickness was 8 inches, being about 6 inches on the brush foundation, and upwards of 10 inches when placed directly on the earth. The cost, exclusive of grading and mattress foundation, was $0.0612 per square foot.

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The approximate cost of completed revetment, 200 feet wide below the zero contour, with bank paved to the two-third stage, as deduced from the season's work, would be per lineal foot:

Clearing and grading	$1.59
Subaqueous mat, 200 feet wide	7.02
Connecting mat, 60 feet wide	3.36
Paving	4.59
	16.55
Proportion of other expenses, 18 per cent	3.01
Cost per lineal foot of revetment	19.56

Accompanying this report is a tabulated statement showing expenditures in detail, with quantity of work done and cost per unit. Also a plan showing the location and dimensions of the work and the soundings.

Respectfully submitted.

W. M. REES,
Assistant Engineer.

Capt. S. W. ROESSLER,
Corps of Engineers, U. S. A.

APPENDIX 5 C.

REPORT OF ASSISTANT ENGINEER C. W. STURTEVANT ON REPAIRS TO PLANT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., May 26, 1892.

CAPTAIN: I have the honor to submit the following report upon the repairs to plant at Amelia, Ark., for the year ending May 31, 1892:

District barges.—Five unserviceable barges, Nos. 55, 74, 76, 94, and 134, had new gunwales and rakes built; the bottoms were found to be in a good state of preservation and only required calking. Barge No. 135 had deck calked and pitched. Other barges in fleet have been calked and patched just enough to keep them afloat.

General-service barges.—Twenty-one barges, Nos. 40, 42, 44, 45, 49, 84, 141, 148, 169, 171, 181, 183, 189, 191, 206, 209, 212, 216, 221, 222, and 253, have been calked and repaired, ready for towing stone.

Mooring barges.—Four first and second district mooring barges were repaired and strengthened for last season's work. Two new mooring barges were built, using old bottoms from other barges, with new gunwales and rakes.

Mattress barges.—Four mattress barges were built, using old bottoms of district barges with new gunwales and rakes.

Quarter boats.—Quarter boat No. 27. Hull calked and patched, cabin and roof repaired and painted.

Quarter boat 11. Hull calked and patched, new rakes, new guards, and roof painted.

Quarter boat 30. Not docked; just patched and whitewashed.

Quarter boat 25. Thoroughly repaired and a set of hog chains placed fore and aft.

Quarter boat No. 6. Thoroughly overhauled while on dock.

Quarter boat No. 39. Cabin repaired and painted, new guards, hull repaired above water line; not docked.

Quarter boat No. 28. Deck and cabin repaired.

Amelia No. 2. Ceiled, put in ventilators and screens.

Calking flats.—Two calking flats were built and two old ones repaired.

Derrick boat No. 2. Hull and machinery received minor repairs and two cars built to unload stone on bank.

Machine boat No. 1. Painted and received only necessary repairs.

Machine boat No. 2. Painted and received only necessary repairs; also a new smoke-stack.

Pile-drivers have received only necessary repairs to hulls to keep them afloat.

No. 39 received a new water chamber for its Worthington pump.

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Hydraulic grader No. 2 has been docked and received new 6-inch yellow pine gunwales and new rakes. This grader has been carefully overhauled both in hull and machinery. Two new water chambers have been placed instead of the old ones that were cracked. Two more openings were made for the flow of water into the wells in which the receiving pipes are placed.

Hydraulic grader No. 4 is now on the dock. A new water chamber was purchased during the season and has been used; one side only of the pump will be repaired, as the other side would require a new high-pressure cylinder and a new water chamber.

Second district grader No. 40 was repaired, calked, and painted; deck shored up under pump, and a fore-and-aft 5-inch yellow-pine bulkhead placed in center of hull under pump; also two sets of rods were placed from top of outside gunwales to bottom of middle bulkhead to assist in holding up the weight of the pump. The cabin and machinery have been overhauled and painted. The heater was found to be very leaky and likely caused the trouble with the vacuum. The main shaft was also found to be in wrong and was changed end for end. A new condenser was purchased during the year.

Steamboats.—Steamer *Titan* has three new boilers, with new boiler beams and breeching, also the system of feeding water into boiler has been changed from the pan in top of shell to a spray in mud drum. Two new and larger hog chain posts aft, two additional center and two additional forward hog chain posts and a second set of main hog chains, two knuckle chains under cylinders and a short chain under boilers fore and aft. Fantail been braced out and held up by a traverse system of chains. Iron straps attached to foot log on forward end of main chains was taken off and rewelded. Shore up main and boiler decks under pilot house. The wheel was rebuilt and painted. Pitman straps enlarged, machinery reset and lined.

Steamer *Graham* has two new boilers in place of old ones worn out, also various other minor repairs to boat and machinery.

Steamer *Kirns* has received only such general repairs to boat and machinery as have been necessary to keep the boat in commission.

Steamer *Itasca* has had a new boiler, the hull, cabin, and wheel thoroughly overhauled and painted.

Steamer *Abbot* had three partially decayed strakes in the hull which were repaired, nineteen new wheel arms were replaced, also a set of buckets complete. Twelve iron straps were placed on each side to tie the deck beams down to the hull. The hull was calked and painted. A second feed pump was placed on the boat in the engine room for use in case of accident to the first one. The machinery reset and lined up, one new sheet placed in boiler, a rigging for raising and lowering meter at stern of boat was also arranged.

Sand pump boat.—The boilers were exchanged for better ones not in use on the fleet; a larger pulley for pump was purchased so that the engine might be speeded up to develop the proper amount of horse power, arrangements were made so as to take steam from boilers on steamer *Graham*.

Warehouse A.—A warehouse for storing boilers and machinery has been built 125 long and 30 feet wide and is raised up 6 inches above high water. It has oak and ash foundation timbers, cypress siding, cottonwood frame, and tin-shingle roof, and tin gutters.

General repairs.—There are many minor repairs to various pieces of plant that are classed under the head of general repairs, they were small amounts and at various times, and were necessary only to care for the plant or in construction of tools which could not be charged to a piece of plant as increasing its value.

There is inclosed herewith table of repairs giving cost of each piece during the year.

Respectfully submitted.

C. W. STURTEVANT,
Assistant Engineer.

Capt. S. W. ROESSLER,
Corps of Engineers, U. S. A.

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Table of cost of repairs to various pieces of plant at Amelia, Ark., from June 1, 1891, to May 1, 1892.

District barge No.—	
55	$1,049.12
74	288.18
76	988.37
94	1,062.99
134	516.51
135	73.80
General-service barge No.—	
40	16.55
42	19.61
44	28.07
45	17.84
49	16.51
84	.55
141	27.55
148	13.86
169	95.19
171	18.16
181	108.96
183	55.13
189	38.35
191	46.15
206	19.97
209	36.75
212	38.40
216	294.96
221	48.52
222	45.75
253	10.71
First district mooring barges (two)	563.18
Second district mooring barges (two)	257.46
Mooring barge No.—	
1	2,903.08
2	1,894.07
Mattress barge No.—	
1	$2,851.20
2	3,011.54
3	2,946.27
4	3,187.23
Quarter boat No.—	
27	240.63
11	620.52
30	275.79
25	915.43
6	505.08
39	417.78
28	67.93
Amelia No. 2	78.17
Calking flats	100.00
Derrick boat No. 2	200.14
Machine boat No.—	
1	67.90
2	147.24
Pile-drivers Nos. 61, 58, 59, 21, and 38	288.84
Hydraulic grader No.—	
2	3,122.34
4	1,101.38
Second district grader No. 40	751.99
Steamer—	
Titian	5,689.30
Graham	2,057.18
Kirns	213.42
Itasca	1,247.40
Abbot	560.78
Sand pump boat	771.79
Warehouse A	1,562.13
General repairs	10,104.78
Total	53,728.48

Abstract of proposals for furnishing stone for use at Hopefield Bend, Arkansas, received in response to advertisement dated June 30, 1891, and opened July 14, 1891, by Capt. S. W. Roessler, Corps of Engineers.

No.	Name and address of bidder.	10,000 cubic yards on barges.	10,000 cubic yards on bank.	20,000 cubic yards on bank.
		Per cu. yard	Per cu. yard.	Per cu. yard.
1	Frederick Hartweg, Cincinnati, Ohio	$1.84	$1.84	
2	Edward Hely, West Plains, Mo	*1.65	*1.75	$1.65

*Accepted.

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Abstract of proposals for furnishing wire, wire strands, rope, etc., received in response to advertisement dated June 30, 1891, and opened July 14, 1891, by Capt. S. W. Roessler, Corps of Engineers.

No.	Name and address of bidder.	90,000 pounds No. 12 wire, per pound.	38,000 pounds No. 10 wire, per pound.	20 coils ⅜-inch strand, per pound.	42 coils ½-inch strand, per pound.	42 coils ⅝-inch strand, per pound.	7 coils 1-inch wire rope, per foot.	6 coils 1¼-inch wire rope, per foot.	25,000 pounds 8 by 7/16 inch boat spikes, per pound.	5,000 pounds 6 by 5/16 inch boat spikes, per pound.
		Cents.	*Cents*	*Cents.*	*Cents.*	*Cents*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	Lee Bros. & Co., Memphis	....	....	4.80	4.80	4.80	†21.83	†26.79		
2	John Manogue, Memphis	....	....	....	....	....	....	....	2.63½	2.63½
3	Orgill Bros. & Co., Memphis	*2.71½	*2.70	*4.40	*4.40	*4.40	*‡6.88	*‡6.88	....	....
4	Livermore Foundry and Machine Co., Memphis.	2.73	2.73	4.71	5.34	5.01	‡14.17	‡14.02	*2.63	2.63
5	Harry E. Coffin, Memphis	2.84	2.79	4.81¾	4.81¾	4.81¾	†21.83	†26.79	*2.54	*2.54

* Accepted. † Per foot. ‡ Per pound.

Abstract of proposals for levee work on Helena Front, Arkansas, received in response to advertisement dated July 30, 1891, and opened August 15, 1891, by Capt. S. W. Roessler, Corps of Engineers.

No.	Name and address of bidder.	Section No. 1, station 765 to 822.60, per cubic yard.	Section No. 2, station 822.60 to 910, per cubic yard.
		Cents.	*Cents.*
1	Cary & Mims, Memphis, Tenn	24	22½
2	Hartnett & O'Brien, Memphis, Tenn	....	*18
3	Oliver Ferguson & Sons, Memphis, Tenn	*18.96	18.96
4	Lowman & Evans, Memphis, Tenn	19	19
5	Keogh & Moore, Memphis, Tenn	19.3	....
6	Timothy Sullivan, Memphis, Tenn	22.4	19.4
7	Ernst Hyner, Greenville, Miss	23.7	22.3
8	Johnson & Outzen, Memphis, Tenn	20¼	18¾
9	Jennings & Co., Memphis, Tenn	21¾	19.24
10	McTighe, Hussey & Co., Memphis, Tenn	20¾	20½

* Accepted.

Abstract of proposals for levee work on Helena Front, Arkansas, received in response to advertisement dated September 9, 1891, and opened September 19, 1891, by Capt. S. W. Roessler, Corps of Engineers.

No.	Name and address of bidder.	Station 910 to 959, per cubic yard.	Station 959 to 1030 per, cubic yard.
		Cents.	*Cents.*
1	Bradburn & Mims, Mound Landing, Miss	24½	24½
2	Francis M. Ferguson, Memphis, Tenn	*16.94	*18.44
3	Timothy W. Scott, Memphis, Tenn	....	23¾
4	Hartnett & O'Brien, Memphis, Tenn	19.95	....
5	Lowman & Evans, Memphis, Tenn	....	20
6	Ware & Donaven, Memphis, Tenn	17⅞	21
7	Robt. Johnson, Memphis, Tenn	21	21
8	Timothy Sullivan, Memphis, Tenn	20	20

* Accepted.

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Abstract of proposals for levee work at Hushpuckana, Mississippi, received in response to advertisement dated September 16, 1891, and opened September 26, 1891, by Capt. S. W. Roessler, Corps of Engineers.

No.	Name and address of bidder.	Price per cubic yard.	Total cost.
		Cents.	
1	T. S. Aderholdt, Friars Point, Miss	18.94	$15,152
2	W. A. Shippey & Co., Memphis, Tenn	$16\frac{1}{4}$	13,000
3	John A. Ware, Memphis, Tenn	$17\frac{3}{4}$	14,200
4	T. W. Scott & Co., Memphis, Tenn	$16\frac{2}{5}$	13,120
5	Jennings & Co., Memphis, Tenn	$17\frac{3}{16}$	13,750
6	Timothy Sullivan, Memphis, Tenn	*$15\frac{1}{2}$	12,400

* Accepted.

Abstract of proposals for levee work at Carson Loop, Arkansas, received in response to advertisement dated October 13, 1891, and opened October 23, 1891, by Capt. S. W. Roessler, Corps of Engineers.

No.	Name and address of bidder.	Price per cubic yard.	Total cost.
		Cents.	
1	Pardesky & Lyman, Memphis, Tenn	*16.95	$5,932.50
2	Timothy Sullivan, Memphis, Tenn	$24\frac{3}{4}$	8,662.50
3	T. S. Aderholdt, Friar's Point, Miss	1740	6,090.00
4	W. B. Richardet, Memphis, Tenn	$17\frac{5}{8}$	6,168.75

*Accepted.

List of civilian engineers employed on works of improving Mississippi River, first and second districts, in charge of Capt. S. W. Roessler, Corps of Engineers, from June 1, 1891, to May 31, 1892.

Name and residence.	Time employed.	Pay per month.	Where employed.	Work on which employed.
	Months.			
Aug. J. Nolty, Chattanooga, Tenn.	9 8	$175 150	Amelia, Ark	Construction; Plum Point Reach.
W. M. Rees, Memphis, Tenn	$11\frac{1}{2}$	200	Memphis, Tenn	Hopefield Bend and miscellaneous work.
C. W. Sturtevant, Appleton City, Mo.	12	150	Amelia, Ark	Surveys and repairs to plant; Plum Point Reach.
Wm. Gerig, Columbia, Mo	$9\frac{18}{30}$	125	Helena, Ark., and Memphis, Tenn.	Surveys, gauges and observations, first and second districts.
Fred. Wigstrand, Memphis, Tenn.	$9\frac{7}{30}$	150	Old Town, Ark	Levees, White River Basin.
A. F. Kilpatrick, Memphis, Tenn.	$11\frac{15}{30}$	125	Beiths, Ark	Do.
S. Elliott Moore, Memphis, Tenn.	3 9	175 125	Hillhouse, Miss	Levees, Upper Mississippi Levee District.
M. Gardner, Memphis, Tenn	$2\frac{13}{30}$	100	Old Town, Ark	Levees, White River Basin.
Louis E. Ritter, Cleveland, Ohio	2	125	Amelia, Ark	Surveys, gauges, and observations, first and second districts.
W. S. Simpson, Cairo, Ill	$5\frac{23}{30}$	75	Old Town, Ark	Levees, White River Basin.
John H. Fields, Memphis, Tenn	$1\frac{13}{30}$	75	Helena, Ark	Surveys, gauges, and observations, first and second districts.
F. A. Fisher, Memphis, Tenn	2	75	....do	Do.
L. Engstfeld, Memphis, Tenn	$2\frac{1}{30}$	135	Memphis, Tenn	Miscellaneous office work.

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River tonnage and passenger traffic for the calendar year 1891.

Name of line or steamers.	Description.		Trips.	Total freight.	Greatest draft.	Average tonnage.	Passengers carried.	
	Steamers.	Barges.					Cabin.	Deck.
				Tons.	*Feet.*			
Memphis and Cincinnati Packet Co	4	....	68	73,902	9	795	*11,762	....
St. Louis and Mississippi Valley Transportation Co	9	87	174	413,779	9½	1,400	....	....
St. Louis and New Orleans Anchor Line	10	....	238	215,058	9½	1,430	31,684	14,056
Steamer State of Kansas	1	....	1	2,300	6	....	30	15
Steamer U. P. Schenck	1	....	6	12,625	9	1,178	815	138
Lee Line steamers	6	....	459	84,357	8	270	20,420	27,549
Steamer New Mary Houston	1	....	7	14,700	10½	1,164	900	600
Arkansas River Packet Co	2	....	57	21,130	4½	548	900	1,263
Memphis and White River Packet Co	2	....	40	13,850	5½	....	728	761
Steamer Guiding Star	1	....	5	11,750	10	1,122	800	175
Steamer Kate Adams	1	....	104	17,619	8	1,200	4,160	6,647

* Includes cabin and deck passengers.

Approximate value of plant belonging to the United States and used upon the improvement of the Mississippi River, First and Second Districts.

Class of property.	No.	Approximate value, May 31, 1892.	Class of property.	No.	Approximate value, May 31, 1892.
Steamer Titan	1	$22,856	Barges	37	26,671
Steamer Kirns	1	7,156	Machine shop boats	2	8,352
Steamer Itasca	1	6,218	Floating dock	1	4,890
Steamer Graham	1	6,734	Flatboats	3	340
Steamer Abbott	1	2,849	Skiffs	31	328
Pile-drivers	20	18,958	Storehouse	1	2,100
Quarter boats	14	17,232	Tools, appliances, and outfit	.....	12,000
Mattress barges	8	18,279	Office furniture	.....	275
Sand pump	1	2,672	Surveying instruments	.....	750
Graders, hydraulic	2	15,547			
Derrick boat	1	1,600	Total	.....	170,807

Improving Mississippi River, First District. Statement of expenditures at Plum Point Reach, from June 1, 1891, to May 1, 1892.

Items.	Construction Fletchers Bend. New work.	Construction Fletchers Bend. Repairs to old work.	Construction Ashport Bend. New work.	Construction Osceola Bar.	Construction Daniels Point. New work.	Construction Daniels Point. Repairs to old work.
Rope	$1,314.54	....	$609.39	$661.59	....	....
Lumber	42.38	....	28.01	5.00	....	$1.58
Brush	8,538.42	$378.42	7,709.16	1,953.30	....	815.49
Poles	2,005.50	63.31	1,779.00	334.50	....	211.50
Spikes	109.43	5.16	66.42	32.66	....	9.94
Iron	101.83	2.38	29.33	16.82	....	3.22
Fittings	85.74	....	1,289.43	252.93	....	125.41
Oils and supplies	224.10	6.10	152.93	65.59	$11.93	14.59
Paints	1.32	....	1.20	.98	....	....
Miscellaneous materials	280.96	3.92	169.09	47.29	....	7.91
Coal	1,167.51	13.52	1,302.99	308.63	92.43	18.98
Towing	2,855.18	200.00	3,098.96	1,672.26	258.42	533.57
Wire	2,516.55	83.86	1,099.13	490.71	....	359.31
Wire strand	604.51	36.94	625.60	150.78	....	92.63
Stone	26,536.01	1,927.87	16,738.96	10,541.18	....	5,411.12
Wire rope	400.30	....	500.00	227.00	....	125.00
Oakum	4.62	....	3.57	3.55	....	3.56
Nails	18.69	....	6.09	5.88	....	.61
Piling	33.90	....	....	1.80	....	....
Labor	21,464.01	1,946.45	16,473.16	10,101.59	639.00	1,958.55
Superintendence	687.59	103.33	477.67	320.75	25.83	219.17
Subsistence	6,101.77	545.60	5,965.32	3,960.03	238.85	955.42
Office and general administration	2,703.51	219.20	2,045.90	1,096.02	438.41	365.34
Total	77,798.37	5,535.06	60,171.31	32,250.84	1,704.87	11,227.90

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Improving Mississippi River, First District, etc.—Continued.

Items.	Unloading stone.	Sinking Drift Elmot Chute.	Sinking Drift Island 30 Chute.	Elmot Chute Dike.	Island 30 Chute Dike.	Totals.
Rope	$114.03					$2,699.55
Lumber	23.60	$18.98				119.55
Brush		338.64				19,733.43
Poles		9.00				4,402.81
Spikes	10.58	8.58	$2.20			244.97
Iron	1.82					155.40
Fittings	.90					1,754.41
Oils and supplies	26.46	1.52				503.22
Paints						3.50
Miscellaneous materials	36.86					546.03
Coal	269.75					3,173.81
Towing	326.05	459.77	191.80			9,596.01
Wire		140.40	55.48			4,744.44
Wire strand		148.85	57.66			1,716.97
Stone		1,721.48	503.72			63,380.34
Wire rope						1,252.30
Oakum	.71					16.01
Nails	.62					31.89
Piling				$2,942.98	$2,942.98	5,921.66
Labor	2,556.17	1,991.03	693.47			57,818.43
Superintendence	127.50	238.33	85.00			2,285.17
Subsistence	801.12	7.30	5.09			18,580.50
Office and general administration	146.13	146.14	73.06	36.53	36.54	7,306.78
Total	4,442.30	5,230.02	1,667.48	2,979.51	2,979.52	205,987.18

Improving Mississippi River, Second District. Statement of expenditures at Hopefield Bend, Arkansas, from September 1, 1891, to March 1, 1892.

Items.	Superintendence.	Care of plant.	Repairs to plant.	Steamers.	Bank revetment.	
					Clearing bank.	Hydraulic grading.
Labor	$2,330.42	$1,654.76	$981.47	$2,652.57	$730.87	$2,026.25
Subsistence	259.82	563.39	236.94	680.18	17.80	504.79
Iron			16.98			.86
Spikes and nails			13.03			
Coal		348.15	295.65	1,913.63		928.15
Lumber			137.06	50.00		
Pipe-fittings, etc			7.19	11.97		24.68
Oils and engineers' supplies		75.50	37.06	51.32		48.42
Paints			47.22	4.73		.40
Oakum			53.50			
Machinery			365.00			
Miscellaneous	7.00	61.22	133.06	48.71	21.00	63.20
Office and general administration	50.58	50.58	50.58	101.16	16.86	50.58
Total	2,647.82	2,753.60	2,374.74	5,514.27	786.53	3,647.31

Items.	Bank revetment.		Subaqueous revetment.		Miscellaneous.	Total.
	Hand grading.	Paving.	Connecting mattress.	River mattress.		
Labor	$1,092.85	$6,574.85	$4,312.54	$3,736.09	$376.03	$26,468.70
Subsistence	57.93	858.76	1,611.51	1,381,19	151.62	6,323.93
Brush			5,190.06	3.427.20		8,617.26
Poles			812.70	681.15		1,493.85
Piling				25.56		26.56
Stone		23,214.71	7,976.10	5,832.75		37,023.56
Wire			870.43	1,058.07		1,928.50
Wire strand			70.62	302.46		373.08
Iron			5.89	28.40		52.13
Spikes and nails			66.04	55.88		134.95
Coal				12.55		3,498.13
Lumber				31.02		218.08
Pipe-fittings, etc					1.10	44.92
Oils and engineers' supplies				2.17		214.47
Paints						52.35
Oakum						53.50
Manilla rope			312.40	937.19		1,249.59
Machinery						365.00
Miscellaneous					192.11	526.30
Office and general administration	16.86	573.24	421.50	320.34	33.72	1,686.00
Total	1,167.64	31,221.56	21,649.79	17,832.02	754.58	90,349.86

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APPENDIX 6.

REPORT OF CAPT. C. M'D. TOWNSEND, CORPS OF ENGINEERS, ON OPERATIONS IN THIRD DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., May 31, 1892.

GENERAL: I have the honor to submit the following report of operations in the Third District, improving the Mississippi River, for the year ending May 31, 1892.

This District extends from the mouth of White River to Warrenton, Miss., a distance of 220 miles. In its improvement, work has been undertaken at Lake Bolivar Front, Ashbrook Neck, Greenville, Lake Providence Reach, Delta Point, and Vicksburg Harbor, and the levees have been constructed and enlarged, in the Lower Mississippi Levee District, and in the Tensas Basin, Arkansas and Louisiana.

LAKE BOLIVAR FRONT.

The object of this improvement was to stop a caving of the bank, which was threatening the destruction of a large levee across the end of Lake Bolivar.

Four thousand, four hundred feet of revetment were built in 1888–'89, as described in the report of the Chief of Engineers for 1889, page 2704, along a portion of which the mats were but 180 feet wide. This section was strengthened in 1889–'90.

This work has accomplished the purpose for which it has been constructed. The caving has been checked at the end of the lake. Below the revetment the caving has continued, but the line of levees there threatened, has been replaced by a line further from the bank, erected by the Lower Mississippi Levee District.

An examination of the work during the low water of last season showed that the subaqueous mat was in good condition, but that at a number of places above the low-water line the brush revetment had rotted out, leaving portions of the bank exposed to the action of the river. It is proposed during the next season to repair these places, replacing the brush by a revetment of stone 10 inches thick.

ASHBROOK NECK.

The object of the work at this place is to prevent the river from cutting through the neck, and thus forming a cut-off, with its resultant disturbance of the regimen of the river. The neck at its narrowest section is but 2,300 feet wide.

The project adopted for this improvement in 1890 consisted in a continuous revetment of the upper side of the neck at its narrowest part, the subaqueous mats to have a width of from 250 to 300 feet, and the upper bank revetment to extend to a two-thirds stage. During the season 1890–'91, 2,820 feet of this revetment was thus constructed, the upper bank revetment being built of brush and stone, but due to a rapid rise in the river at the close of the season the subaqueous mat for the last 500 feet was only given a width of 180 feet.

After the flood of 1891 it was found that scouring had taken place at the foot of the mat 180 feet wide to such an extent as to endanger its stability.

The approved project for this season's work was to repair the portion of revetment of last year which had been undermined, and extend it 2,500 feet below the completed work and 3,500 feet above, substituting a riprap of 10 inches of stone for the upper bank revetmentment of brush and stone previously employed, and giving the upper bank a slope of 1 on 4 in place of 1 on 3.

Work was begun August 24, 1891, and suspended January 28, 1892, on account of the high stage of the river. Over the damaged mat was sunk a mat 300 feet wide, and 2,500 feet of revetment was completed below that of last season. Work was then begun on the upper portion of the project, but the rising of the river necessitated the suspension of operations when 1,300 feet of the bank had been revetted. The cost of the revetment was $30.83 per linear foot.

To prevent a flow of water across the neck, a levee was constructed parallel to the axis of the neck, as shown on the accompanying map. The levee was given an elevation equal to that of the main line of levees opposite to which it was located, with a crown of 4 feet and slopes of 1 on 2½. Its length was 7,300 feet. This levee has been seriously injured during the existing flood. The extent of the damage will not be determined until the water subsides.

A detailed description of the work will be found in the accompanying report of Mr. Arthur Hider, who was in local charge. Credit is due to Mr. Hider and the employés at Ashbrook Neck that so much revetment was constructed at this place and at so low a cost, especially when it is considered that the changes in plan necessitated the expenditure of nearly 2 cubic yards of stone per running foot more than was employed last season, and that plant, material, and labor were often diverted from it to insure the completion of the more urgent work at Greenville.

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REPORT OF ASSISTANT ENGINEER ARTHUR HIDER.

The following report of work on the Ashbrook Neck improvement the past season gives a description of the work done, the quantity of material used, and the cost of the different items in detail. Work was begun August 24, 1891, and was suspended January 28, 1892, on account of the high stage of the water and the lateness of the season.

Description.—The project for the season's work, as approved, was the continuation of the revetment begun last year, both above and below the completed work; 3,500 feet above and 2,500 feet below, making a total length of 6,000 linear feet. Work was first begun at the lower end, where the wide 300-foot mats built last season terminated. After finishing this part of the project work was begun above, but only 1,300 feet of the 3,500 was completed before work had to be stopped on account of the high stage of the river.

The work here was identical with that done at Greenville, subaqueous mattresses from 250 to 300 feet in width, so as to extend out to the deepest water, upper bank graded to a slope of 1 on 4, and covered with 10 inches of riprap to the two-third full stage, which was taken at 32.8 feet on the Arkansas City gauge, the height of the brush revetment being restricted to 5 feet above the stage of water existing at the time the mattresses were constructed.

Clearing.—Before beginning the grading the upper bank was cleared of undergrowth, trees, and stumps, as the timber grew close to the river, in all 22.4 acres of clearing was done, at a cost of $71.50 per acre.

Grading.—Along the lower part of the work the bank was of hard material, and the rate of progress made was not so rapid as at the upper end, where the bank was composed of layers of sand and buckshot. Work was begun on August 24, and the grading finished January 5. Grader No. 3 was in service from the beginning, and Grader No. 77 from November 21 until the grading was finished. A single line of 4-inch hose was used on Grader No. 3, and a single line of 2½-inch hose on Grader No. 77. The smaller grader, No. 77, gave good results where the bank was not excessively hard, and, considering the cost, was fairly economical. The pressure used on Grader No. 3 was steam 90 pounds, water 160 pounds per square inch; on Grader No. 77, steam 100 pounds, water 150 pounds. The length of bank graded was 5,155 linear feet; the average rate of progress made was 46.9 feet, the cost of hydraulic grading, $1.21 per foot, and the cost of dressing up and filling holes to bring the slope to an even grade was $0.46 cents, making the cost of a linear foot of completed grade $1.68.

Mattress construction was begun September 7, and the last mat sunk on January 16, 1892. Seven mats were built, the size of these varied from 475 to 1,200 feet in length, and from 250 to 300 feet in width. Two shore mats were constructed; one in front of the eddy just above the upper end of last season's work, to join the main mattress with the shore; this was 350 feet long by 97½ feet wide; and the other 400 feet long by 140 feet wide; to cover the slope at the lower end of the work, in front of which the main mattress had been sunk before the upper bank had been graded.

Mattress No. 6 as built was 770 by 275 feet. In sinking this mat it broke in two about 150 feet from the head, and the lower 600 feet was lost. As great care had been taken in the construction of this, as well as all the other mats, and the usual precautions taken in sinking, the loss can not be attributed to any other cause than the fact that the mat had been ballasted ready to sink for nearly two days, which on account of heavy drenching rains could not be done, and that on the evening before the attempt to sink was made, a violent storm of wind and rain occurred, causing the waves and swells to break over the partly submerged mat, bringing into force abnormal strains that the mat was not designed to withstand, weakening the fastenings, and probably breaking some of the poles. The result was that after the head was sunk safely on the bottom, the construction after being subjected to this ordeal was not strong enough to endure the excessive strains which were then brought in play by the position of the mat, part on the bottom and the rest floating on the surface. The mat tore, apparently the longitudinal poles first breaking, and afterwards one after the other the longitudinal cables, of which there were fourteen in the width of the mat. The head lines and the first two cross cables held, and the upper 150 feet were sunk in place.

The method of construction and the size of fastenings used, are fully described in the report of the Greenville Harbor improvement, with which it was identical. In all 12,587 squares of mat were built and sunk in place, at a cost of $4.69 per square, and 971 squares of shore mat, at a cost of $5.33 per square.

Upper bank work.—The riprap was carried up in advance of the rising water, except at the extreme lower end of the work, where it was necessary to build a connecting mat to join the main mat with the bank. As this was built near the close of the season, when the water was at a comparatively high stage, it was necessary to distribute the rock from barges to cover this part of the slope, which is about 400

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feet in length. Care was taken to distribute this as nearly as possible to the required depth of 10 inches.

Material.—Brush and poles were obtained by contract. The average distance this was towed was 60 miles. Stone was procured from the reserve left over from last season's work, from Arkansas City, from Memphis, and two barges from the Ohio River. The progress of the work was much retarded on account of the uncertain and intermittent supply of stone, and as a consequence of this, the entire project could not be completed. There yet remains to be done 2,200 feet of revetment at the upper end.

In the beginning of the season the work suffered for want of sufficient plant. It was not until the latter end of October that a sufficient number of barges was available for the needs of the work. These causes, with the difficulty of adjusting the labor force economically to the above conditions, have rendered the cost of the work more expensive than it otherwise would have been.

Levee.—The levee built parallel with the axis of the neck, to prevent the current at high water flowing across and precipitating a cut-off, which the revetment work was designed to prevent, was built by contract. The levee is 1 foot above the high water of 1890 (at the upper part of the bend, about 2 miles above the site of the work), crown 4 feet, slopes 1 on 2½. The work was begun December 11, 1891, and finished February 20, 1892. The total length, 7,300 feet. The amount and cost was:

56,676.3 cubic yards of embankment, at 16⅔ cents	$9,422.44
Extra work revetting ends	137.09
Total	9,559.53

This amount is not included in the statement of cost of revetment.

The amount and value of material expended was as follows:

Brush (12,361.5 cords)	$14,501.88	
Poles (2,155.8 cords)	3,772.67	
Stone (24,768 cubic yards)	48,357.75	
Loading stone	4,701.13	
Wire (97,589 pounds)	2,771.53	
Wire cable (74,087 pounds)	3,474.55	
Spikes (13,225 pounds)	460.51	
Coal (45,470 bushels)	6,237.04	
Medicines	102.20	
Oil (1,628 gallons)	418.91	
Lumber (14,869 feet)	258.88	
Staples (310 pounds)	34.00	
Clevises (1,260 pounds)	54.12	
Sundry supplies	402.88	
Permanent supplies and property	2,280.58	
		$87,828.63
Labor pay roll	38,273.11	
Subsistence	9,735.24	
		48,008.35
Repairs		552.32
Traveling expenses		447,75
Stationery and office		238.43
Miscellaneous		445.85
Total		137,521.33

Dividing this amount by the length of the bank revetment $\frac{137,521.33}{4,460}$ gives the cost per linear foot for this class of revetment, $30.83.

The percentage of cost of the different items was:

Items.	Cost.	Per cent.
Material, supplies, etc	$87,882.60	64.0
Towing	10,096.74	7.3
Labor	27,871.52	20.3
Subsistence	8,036.99	5.8
Office and traveling expenses	685.98	0.5
Superintendence	2,947.50	2.1
Total	137,521.33	100.0

NOTE.—The labor cost of loading stone is added to the value of material as the cost of stone.

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Below is given the size of mats constructed:

	Linear feet.	
No. 1	565 by 300	
No. 2	475 by 300	
No. 3	845 by 300	
No. 4	1,200 by 250	
No. 5	600 by 300	
No. 6	150 by 275	
No. 7	625 by 275	
		12,587 squares.
Lost	620 by 275	1,705 squares.
Total amount built		14,292 squares.

The actual length of bank covered with riprap, revetment, and subaqueous mattress, was 4,460 linear feet. The quantity of brush used per square of mat, was, brush, 0.661; poles, 0.132; total brush and poles per square, 0.793 cord. The quantity of stone used per square of subaqueous mat, was 0.688 cubic yard, on upper slope, and revetment 2.89 cubic yards. The average width of the work from top of slope paving to outer edge of mat is 418.7 feet. The quantity of brush and poles used per linear foot of completed work was 2.565 cords; stone, 5.136 cubic yards; wire cable, 14.8 pounds; wire, 19.517; spikes, 2.6 pounds. The average number of men employed was 144; the average cost of subsistence was 42.4 cents for each day's labor secured. A detailed list of expenditures, labor, cost, etc., is forwarded herewith (omitted); this gives an analysis in detail of the labor and material cost of the different items of work, a synopsis of which is embodied in the following statement:

Tabulated statement.

Kind of work.	Labor and subsistence.	Material.	Total.	Total cost.
	Cost per unit.	*Cost per unit.*	*Cost per unit.*	
Mat work .... squares	$1.573	$3.117	$4.690	$59,033.45
Foot mat .... do	1.719	3.616	5.335	5,180.26
Revetment .... do	2.388	6.809	9.197	21,907.26
Paving bank .... do	1.617	7.006	8.623	23,585.42
Clearing bank .... acres	71.50		71.50	1,601.58
Loading stone .... cubic yards	0.589		0.589	2,903.35
Hydraulic grading .... linear feet	0.841	0.369	1.210	6,248.91
Dressing grade .... do	0.457		0.457	2,357.08
Towing				10,096.74
Transportation				447.75
Property and plant				2,217.58
Repairs				552.32
Stationery and office				238.43
Miscellaneous				440.85
Drugs				102.20
Sundries				608.15
Total				137,521.33

$137,521.33 ÷ 4,460 (linear feet) = $30.83 per linear foot. The addition of the work lost would reduce the cost per linear foot nearly one-seventh.

GREENVILLE, MISSISSIPPI.

The object of the improvement at Greenville has been to prevent the caving of the bank at this locality, which was rapidly destroying the city. In 1887 and 1888 ten spur dikes were constructed in front of the town, which checked the caving along the city front. The caving, however, continued above, and threatened to flank and destroy the spurs completed. To check this tendency two spur dikes were constructed in 1889, at a distance of 1,500 and 2,000 feet, respectively, above the series of 1887. These spurs preserved those in front of Greenville during the flood of 1890, but the caving continuing above them, the spurs of 1889 formed a sharp salient, projecting into the river. The flood of 1891 cut across this salient, destroying these spurs. The caving then rapidly extended down the river, eating into the bank from 800 to 900 feet, and flanked the two upper spurs of the series of 1887 and 1888.

The project as approved for this season's work was to revet the bank for about 6,000 feet above the upper remaining spur with a continuous revetment, similar in character to that adopted at Ashbrook Neck. The width of mat was 300 feet, and the height to which the stone riprap was carried was 30 feet on the Greenville gauge.

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The total length of bank revetted during the season was 6,600 feet, at a cost of $29.517 per running foot, estimating the cost of towing stone delivered by the general service, at $1.50 per cubic yard. It was necessary to supplement the supply of stone obtained from the general service, and by contract by rail at Greenville, with stone from the Ohio River, West Memphis, and Arkansas City. Difficulty was experienced in supplying this stone at the close of the season with sufficient rapidity to keep ahead of the rising river, and the necessity was again emphasized of having a sufficient supply of stone on hand at the beginning of the season to complete the work.

A detailed description of the work done, quantity of material used, and the cost of the different items is given in the accompanying report of Assistant Engineer Arthur Hider.

REPORT OF ASSISTANT ENGINEER ARTHUR HIDER.

The work was begun on August 11, 1891, and finished February 1, 1892.

Description.—The project as originally submitted was for continuous revetment above dike $4\frac{1}{2}$; the connection of this dike and the one immediately below, with the shore.

The revetment to cover 6,000 feet of the bank (the subaqueous mats to be 300 feet wide), the upper slope to be 1 on 3, to be covered with stone riprap 10 inches thick up to about the two-thirds stage, or 30 feet on the Greenville gauge.

The project as finally approved was modified by changing the upper bank slope to 1 on 4, and restricting the height of the brush revetment to 5 feet above the stage of water existing at the time the mats were constructed. Work was begun August 1. The interval between that time and the 10th was spent in organizing the force, getting material in readiness, and towing the plant to the site of the work.

Grading.—Hydraulic grading was begun on August 10, with grader No. 1, which worked continuously until October 7, with a single crew. From this date until November 13, at which time hydraulic grading was completed, a night crew was employed, as it was found that the day force alone was insufficient to keep ahead of the mat building. On the completion of the grading, the hydraulic grader was transferred to Louisiana Bend.

A great deal of extra work became necessary, by reason of the nature of the soil along the front. Except for about 1,500 feet below the head of the work, the bank is nearly all pure sand, which gullied badly while being graded, due to the water running down the slope. Large washouts occurred, and it was found impracticable to grade the bank to the required slope with the grader alone. Recourse was at first had to hand work to fill these holes, but the quantity of work required rendered it necessary to employ some cheaper, and more expeditious method. Teams with drag scrapers were used for the heavier part of the work, at a considerable saving in time and money. The cost per linear foot of this imperfect work done by the hydraulic grader was 75.2 cents, and the rate of progress made averaged 65.3 linear feet per day. The cost for dressing the slope, filling up holes, gullies, and washouts, with drag scrapers and hand labor combined, averaged $67\frac{1}{2}$ cents per linear foot, making the cost of a linear foot of completed grade, $\$1.42\frac{7}{10}$. On the whole, 4-inch hose with a single nozzle $1\frac{3}{4}$ inch in diameter, gave the most satisfactory results. Two streams from $2\frac{1}{2}$ inch hose, with three-quarter inch and 1-inch nozzles, were tried for a time, and, although less gullying took place, the progress was so much slower that a return was made to the 4-inch hose with $1\frac{3}{4}$-inch nozzle, on the score of economy. The pump pressure used was 160 pounds, both with the single and double lines of hose, and a steam pressure of 80 pounds per square inch.

Mat building.—Work of mat construction was begun on August 11, and the last mat was sunk in place on December 31. In all, nine (9) mats were built, each 300 feet wide, and varying in length from 449 to 1,036 feet. The usual method of construction was employed; weaving poles of cottonwood and willow eight (8) feet apart, the willow brush woven over and under these poles diagonally, $\frac{5}{8}$-inch wire cables consisting of nineteen strands of No. 12 wire, were used to strengthen the mat longitudinally, the number used varying from eleven to fourteen, depending on the stage of water, and rapidity of the current. Cross cables, extending from the outer edge of the mat up the graded slope, were woven in the mat at distances apart of every 100 feet, and securely fastened on the top of the bank to deadmen. Where the current was not too strong, the two longitudinal cables next the shore, and the cross cables extending to the top of the bank, were of $\frac{3}{8}$-inch diameter, composed of seven strands of No. 11 wire. For holding the mat in position during construction, ten steel 1-inch wire cables, with suitable shackles, and $1\frac{1}{2}$-inch steel pins for connecting one with another, and for fastening to the head of the mat, were used. These cables were in 200 and 400 feet lengths. The lead of these cables was from 400 to 800 feet (when in position), with shore ends securely fastened to trees, or "deadmen." The mooring barges at the head of the mat were held in place by four or six 2-inch ma-

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nilla lines. The slip lines used for lowering the mat in place were of 1¼-inch manilla rope, placed at intervals of about 16 feet apart, across the head of the mat. On one or two of the mats, where there were cross currents, "Chinese anchors" were used; these were sunk out in the river, and connected with the outer edge of the mat by ⅝-inch wire cables, to prevent the mat buckling while sinking. Two or three of these were used to each mat. No unusual trouble was experienced in sinking any of these mats. When it is considered that the largest mat covered an area of more than 7 acres, and was sunk in a current of between 2 and 3 miles an hour, the care necessary to sink this mass of brush, and the difficulties to be overcome, can be better understood.

The total length of bank covered by the subaqueous mattress work was 6,600 linear feet, and the number of squares (10 feet by 10 feet) was 20,334. The cost per square for the completed mattress work was $4.50.

Upper bank work.—In front of Mat No. 2 the brush revetment was carried up to the 30-foot stage, to afford a foundation for the riprap; for the remainder of the work, following the modified specifications, the brush revetment was extended only to the height of from 10 to 20 feet above zero, this height depending on the existing stage of water at the time the work was done.

Riprap 10 inches thick was laid on the upper slope of the bank, from the zero stage to 30-foot stage above the water surface. The stone was carefully laid by hand above the water surface; below the water it was distributed, as near as could be done, so as to make the stone covering the required 10 inches thick. By way of experiment, 100 feet of the upper slope was laid with quarry spalls, which promises to make a close, compact covering, and to answer equally well with the larger stone. A layer of broken stone, of same thickness as the larger riprap, would perhaps make a better covering for the upper slope, as it would be impervious to water, but the additional expense would hardly be justified on this account, as an examination of the work after the river had subsided showed that the interstices between the larger stones had been filled by deposit and sediment; the stones themselves were securely embedded in the ground, making, practically, an equally good protection to the bank, and with the advantage in favor of the large stone as to resisting wave wash.

Material.—The brush and poles were delivered by contract. The average distance of towing for this material was 31 miles. Part of the stone was delivered by the general service before the beginning of the work, part by rail, on the bank of the river at Greenville under contract, and the remainder near the close of the work was obtained from Memphis, Arkansas City, and the Ohio River on barges. The stone delivered by the general service was unloaded on the bank at Greenville and reloaded after the work began; that received by rail was loaded on barges as it was delivered. The cost of this work averaged 45½ cents per cubic yard. The large cost was due to the high bank and long distance the stone had to be moved. The experience of former seasons was again repeated—"insufficient stone for the actual needs of the work." This was due to two causes; the falling behind of the delivery at Greenville and the difficulty of supplementing this deficiency by river at the time when most needed on account of the low stage of water.

During the latter part of December the river rose so rapidly that early in January, for a distance of about 2,000 feet at the lower end of the work, the slope was submerged from 2 to 5 feet before it could be paved, on account of the scarcity of stone. The unusual rapid fall in the river which followed, allowed this work to be afterwards paved and completed. The necessity of having stone on the ground early in the season is imperative, if the work is to be done economically. Had a sufficient quantity of stone been available during the entire season the work could have been finished a month earlier, and at a very considerable reduction in cost.

An examination of the work a month after completion shows defects in the slope paving in a few places, due to surface water after heavy rains flowing down the slope and undermining the riprap.

A catch-water drain on top of the bank to intercept the surface water, with outlets at intervals to the river, over paved aprons, is recommended for all future work of this class to remedy this.

The quantity and value of material used is as follows:

Brush (17,331 cords)	$19,063.00
Poles (3,151 cords)	5,514.42
Spikes (15,600 pounds)	404.04
Wire (137,978 pounds)	3,849.57
⅜-inch wire cable (24,002 pounds)	1,154.49
⅝-inch wire cable (78,016 pounds)	3,752.56
Stone (40,271.2 cubic yards)	63,733.73
Coal (50,149.3 bushels)	6,723.06
Lumber (11,915 feet)	224.04
Oil (2,369 gallons)	568.19

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Medicines	$261.05
Clevises (800 pounds)	33.20
Staples (300 pounds)	8.99
Supplies	242.82
Permanent supplies, one-half cost charged	2,224.74
Labor	57,205.45
Subsistence	14,057.28
Traveling expenses and transportation	434.13
Office expenses and stationery	701.97
Repairs and miscellaneous	340.45
Total	180,497.18
To this is added the estimated cost of towing 9,550 cubic yards of stone delivered by the United States, at $1.50 per yard, which should be included in cost of the work	14,318.38
Total	194,815.56

Dividing this amount by the length of bank revetment, $\frac{194,815.56}{6,600}$ gives the cost per linear foot for this class of revetment $29.517.

The percentage of cost of the different items is:

Items.	Cost.	Percentage.
Material and supplies	$131,055.82	67.30
Towage	13,075.74	6.70
Labor	36,454.02	18.70
Subsistence	10,944.72	5.60
Office and traveling expenses	1,136.10	0.60
Superintendence	2,149.16	1.10
Total	194,815.56	100.00

NOTE.—The labor cost of loading stone is added to the value of material as the cost of stone.

Below is given the size of the mats constructed:

No. 1, 600 feet by 300 feet.
No. 2, 600 feet by 300 feet.
No. 3, 700 feet by 300 feet.
No. 4, 850 feet by 300 feet.
No. 5, 1,036 feet by 300 feet.
No. 6, 808 feet by 300 feet.
No. 7, 923 feet by 300 feet.
No. 8, 812 feet by 300 feet.
No. 9, 449 feet by 300 feet.

6,778 linear feet = 20,334 squares.

The actual length of river bank covered was 6,600 linear feet, 178 linear feet of mat being taken up by overlaps. The quantity of brush used per square of mat was 0.70 cords of brush, and 0.13 cords of poles. Total brush and poles per square, 0.83 cords. The quantity of stone used per square of subaqueous mat was 0.64 cubic yards; on the upper slope paving, 3.54 cubic yards. The average width of the completed work from top of slope paving, to outer edge of mat, is 427 feet.

The quantity of brush and poles used per linear foot of completed work was 3.11 cords; stone, 6.12 cubic yards; wire cable, 15.46 pounds; wire, 20.9 pounds; spikes, 2.4 pounds. The average number of men employed was 191; the average cost for subsistence was 48.9 cents for each day's labor secured.

A detailed list of expenditures, labor cost, etc., is forwarded herewith (omitted). This statement gives an analysis in detail of the labor and material, cost of the different items or work, a synopsis of which is embodied in the following statement:

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Tabulated statement, 1891-'92.

Kind of work.	Labor and subsistence.	Material used.	Total.	Entire cost of work done.
	Per unit.	*Per unit.*	*Per unit.*	
Mattress.................................squares..	$1.332	$3.167	$4.499	$91,457.62
Revetment.................................do...	2.042	7.502	9.544	43,245.97
Paving bank...............................do...	1.121	7.474	8.594	33,147.08
Grading bank........................linear feet..	.5387	.2136	.7523	4,965.13
Dressing grade............................	.6755	.00	.6755	4,458.64
Loading stone....................cubic yards*..	.452	.003	.455	....
Towing....................................	....	....	....	13,075.74
Sundries..................................	....	....	....	1,104.54
Office expenses...........................	....	....	....	701.97
Transportation............................	....	....	....	434.13
Property and plant (one-half value).......	....	....	....	$2,224.74

* Money cost of this work included in cost of material.

$194,815.56 ÷ 6,600 (linear feet) = $29.517 per linear foot.

* NOTE.—$14,318.38 is taken up in the above statement as the estimated cost of towing for stone received from the general service.

LAKE PROVIDENCE REACH.

This reach extends from Carolina Landing, Miss., 517 miles below Cairo, to Island 95, a distance of 35 miles.

Before its improvement was undertaken a depth of but 4½ feet at low water had been reported on some of the crossings. (Report of Mississippi River Commission, 1883, page 408.)

The plan of improvement has consisted in the construction of permeable dikes, to close chutes, and contract wide portions of the river, and of bank revetment, to prevent caving.

Strong levees have also been constructed on both banks through this reach.

Dikes have been built at Duncansby Crossing, Cottonwood, Mayersville, Elton, Baleshed, and Stack Island, and are fully described in previous reports of the Commission. Their effect has been beneficial. A deposit of from 6 to 18 feet was formed behind them the first season, chutes were closed, and the river at low water contracted and confined to a single channel. The least depth that has been recorded on crossings in Lake Providence Reach since their construction, has been 7 feet. The following are the soundings obtained at crossings during the extreme low water of the past season:

	Feet.		Feet.
Cordell Crossing	15	Longwood (opposite existing dike)..	28
Duncansby..............................	12	Ben Lomond..........................	12
Homachitto	13	Ajax	10

At a higher stage, but 7½ feet was reported on the Ben Lomond crossing, by pilots. The extensive caving of the banks, however, which has extended from Louisiana Bend through this reach, has successively flanked and destroyed those dikes, until the Baleshed and Stack Island systems alone remain, while opposite them the caving is removing the channel of the river, each year, farther from their sphere of action.

Bank revetment has been undertaken at Mayersville Island and Louisiana Bend. The first attempts were unsuccessful. The caving continued above the points protected, and flanked and destroyed the works. But the revetment constructed at Louisiana Bend in 1889, 6,024 feet in length, has successfully withstood the action of succeeding freshets.

During the past season this revetment has been extended to Station 1,124, 5,224 feet having been constructed. As the mat boats of the district were in use at Ashbrook Neck and Greenville, two large barges were utilized for the purpose. The width of mat was 270 feet, as wide as could be constructed upon them. They extend to a depth of water, at the time of construction, of from 65 to 85 feet.

These mats were connected to the irregular bank by twelve pocket mats. The upper bank revetment was a riprap of stone, 10 inches thick, to a 27-foot stage, and extended from the work of 1889 to the mouth of Old River. The mouth of Old River was protected by a revetment of brush and stone. The work cost $26.49 per linear foot.

A detailed report of the season's operations will be found in the accompanying report of Assistant Engineer E. C. Tollinger, who was in local charge.

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REPORT OF ASSISTANT ENGINEER E. C. TOLLINGER ON OPERATIONS AT LOUISIANA BEND, LOUISIANA, FOR THE SEASON ENDING JANUARY, 1892.

Construction.—Work was completed from Station 0 (△ Owens) to Station 60 in 1889. No work was done in 1890. An examination made in September, 1891, of the work done in 1889, showed it to be in good condition, except about 200 linear feet of the extreme lower end that had been injured by the action of the water cutting the bank away. Work was begun September 17, 1891, and completed January 22, 1892, and extended from Station 58 to Station 110+24 feet, a distance of 5,224 linear feet. The entire plant was moved to Greenville, Miss., the last arriving there on January 25, 1892.

General plan of the work.—A deep-water mat 270 feet wide was first made and sunk on a line that reached to about the deepest water. These were overlapped with pocket mats north of Old River, and connected with brush revetment work across the mouth of Old River, extending to the top of the bank or a 15-foot stage of water. North of Old River, and extending from the line of the pocket mats, the bank was riprapped, 10 inches thick, with rock on a slope 5-4 and 3 to 1, to a 27-foot stage of water. Seven-tenths of cubic yard of rock per square was used on the deep water, and 1½ yards per square on pocket mats and brush revetment.

Towboats.—The steamer *Vidalia* (with the exception of five days at Greenville and Offuts, while the steamer *Osceola* and tug *Parker* were having burnt boilers repaired) was constantly employed. A single crew was employed until the 9th of December, when it became necessary to put on a double crew. The unsound condition of her timbers above water line involved much care upon the captain and engineer to keep her ready at all times for active duty.

The steamer *Vedette* is the most economical for harbor work, if the conditions are favorable, than any of the towboats in the employ of the Third District. She is exclusively a harbor boat.

Grading (hydraulic).—Grading was commenced September 15 and finished December 21; 3,390 linear feet was graded. Our first experience was with a grader that had been constructed from the several parts of broken down machinery. After repeated breakdowns the weak parts were replaced with new ones, but the season had so far advanced that it was necessary to send Grader No. 1 from Greenville Harbor, after completing her work there, to take the place of Grader No. 77. She arrived with a double crew, ready for work, November 13, 11:30 p. m. The water cylinders were leaking, and the pressure had to be reduced from 160 to 125 pounds per square inch. Without the foreman in charge of night force has had special training in this particular line, the bank graded is left in such a bad condition that little or nothing is accomplished.

Deep-water mats.—These were begun September 21 and the last one sunk December 22. Five thousand three hundred and sixty linear feet of 270 feet wide was made and sunk. Eight longitudinal ⅜-inch wire cables were used the full length of the mat. The ⅜-inch transverse wire cables were used every 50 feet. The shore lines being very irregular, the mats were built straight from point to point that projected into the river, that they might reach about out to the deepest water. The mat boats were only 270 feet long. The depth of water was from 65 to 85 feet on the outside of the mats, at a low stage of the river.

Wiring the mat.—This is one of the most important parts of mat construction. There is so much depending upon this part of the work that a thorough examination should be made of every square before ballasting.

Cables are intended to strengthen the mat and to prevent breaking while sinking. The longitudinal ones answer a good purpose. The transverse ones are of doubtful value after the mat has been sunk. As holding-in cables they are of little or no value should the mat start out.

Ballasting should receive careful supervision. Careful notes should be made of the direction and force of the current, and the work done in accordance with the difficulties you are expected to meet.

Sinking.—Stone should be put on the mooring barges to sink the head of the mat. This should be done at the time the mat is being ballasted. Every little detail should be computed and every precaution taken that will insure success. You are not warranted, under the most flattering conditions, of taking chances.

Pocket mats.—The hard, projecting parts along the shore made it necessary to construct 12 mats in the first 3,000 linear feet. These were, with the exception of 3, built in lengths of 270 feet, and vary in widths from 75 to 225 feet.

Riprap (stone).—The bank for the first 3,390 linear feet was graded to a slope of 5, 4, and 3 on 1, and covered with rock 10 inches thick to a 27-foot stage of water. I am of the opinion that 6 inches, well laid, to a ¼ and ¾ stage, is sufficient.

Brush was obtained close by. In size it was too large, but the want of barges did not warrant making a change. By constant urging the contractor did fairly

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well, but the little shortage from day to day added to the cost of the work. The contractor was at all time promptly supplied with barges.

Poles.—The first poles were loaded on barges 75 miles up the river. The quality was in accordance with the specifications. The scarcity of barges and the great distance prevented promptness at all times on our part.

Rock.—The rock was unloaded on the bank at Ashton, La., prior to construction. Most of it was unloaded at points not accessible at extreme low water, thus materially adding to the cost of loading. The unfavorable conditions were improved at a 12 and 15 foot stage of water. Twenty-five thousand seven hundred and four and eight-tenths cubic yards were loaded on barges and towed to the work. About 70 per cent loaded with barrows, 30 per cent with rock cars; these proved very satisfactory.

Conclusion.—The work is, I believe, the best of the kind. The results were obtained by constant and persistent energy, experience, and thoughtfulness on the part of the principal employés.

I make special mention of the valuable service rendered by W. M. Keller, in charge of the office; C. H. Wilson, superintendent of construction; N. Stephany, in charge of the mattress work, and C. A. Lacy, timekeeper.

Itemized accounts, tabulated statements showing amounts charged and expenditures and the cost of the different kinds of work, and progress sketch, accompany this report. (Omitted.)

GENERAL REMARKS UPON BANK REVETMENT.

In the following table is given the amount of revetment which exists in the third district:

	Total constructed.	Constructed, 1891-'92.
	Cubic feet.	*Cubic feet.*
Lake Bolivar Front	4,400	....
Ashbrook Neck	6,780	4,400
Greenville	6,600	6,600
Louisiana Bend	11,240	5,224
Delta Point	10,700	....
Total	39,720	16,284

In addition to the above, about 3,500 feet of Greenville Front is protected by spur dikes. It will be noted the large proportion of this work which was constructed during the last season; but it may also be stated that if any material improvement in the low-water channel is soon to be expected in the 220 miles of river in the Third District, this rate of progress must be largely exceeded.

The amount of work done last season would have been an impossibility if forty barges and the steamboats *Etheridge* and *Vedette* had not been temporarily transferred from the general service to this district.

With this addition the plant was employed to its utmost capacity. Barges were converted into mattress boats, and a grader extemporized from the machinery of a condemned pile-driver. The graders were worked night and day, and while for some time six towboats were in commission, it was necessary on the three largest to employ double crews. Ashbrook Neck suffered especially from lack of plant, while at Greenville, it was with great difficulty that stone could be obtained with sufficient rapidity to complete the work.

The following is a list of the aggregate amounts of the principal items of material expended during the season.

Stone	cubic yards.	90,794	Wire strand	pounds.	267,229
Brush	cords.	47,179	Spikes	do..	37,525
Poles	do..	7,989	Lumber	feet, B. M.	57,826
Wire	pounds.	339,017	Coal	bushels.	118,260

About 7,700 cubic yards of stone were towed a distance of 248 miles, 5,700 cubic yards a distance of 40 miles, some of the brush and poles a distance of 90 miles. The necessity of accumulating large amounts of material, particularly of stone, near the work before beginning operations was again demonstrated. During the months of December and January all the stone which could be delivered by three railroads was accepted, and was insufficient to meet the demand.

The futility of depending upon delivery by barges from the upper Mississippi or

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Ohio rivers was also again shown, but 2,429 cubic yards being received of 10,000 cubic yards which were to have been delivered. The failure at a critical period of this expected supply was the cause of the difficulties experienced at Greenville.

The reduction in cost of work this season is also very satisfactory. The estimated cost per running foot of the revetment constructed at Louisiana Bend in 1889 was over $40. Its extension this season was at a cost of $26.45 per linear foot. It should be noted, however, that across the mouth of Old River the bank only extended to a 15-foot stage. I estimate the cost of the 3,380 feet between the old revetment and the mouth of Old River at about $28 per linear foot. It is believed that a further reduction in cost can be obtained.

In the form of revetment now adopted about 6 cubic yards of stone are used per running foot. The cost of stone delivered on the bank at Louisiana Bend, either by the general service or by contract, has heretofore been over $2.25 per yard.

After the close of last season's work the experiment was tried of towing stone with the plant of the third district. Bids were received for stone loaded on barges in the Little Red, a branch of the White River, at 49 cents, 60 cents, and 65 cents per cubic yard. As these quarries are over 200 miles nearer the work than those on the Upper Mississippi and Ohio, a reduction in the cost of towing is anticipated, though the tow boats of the third district are not well adapted to the purpose.

In a fine, sandy soil, such as was found above Greenville, the 10 inches of stone which were substituted this season for the upper bank revetment of brush and stone previously employed appear to protect the sand from the river currents, but they do not afford an adequate protection, either from wave action, caused by a strong wind blowing on shore, nor from the action of rain water flowing down the slope, during a low stage of the river. In both these cases the water has sufficient force to carry through the interstices of stone large quantities of the sand, forming gullies and cavities, into which the stone settles. An underlying layer of gravel, it is believed, would check this action, and if covered by a thin layer of stone would be in no danger of being carried away by river currents. At Greenville satisfactory results were obtained for a short length of bank by using a revetment of quarry spalls and the refuse of the stone pile.

DELTA POINT AND VICKSBURG HARBOR.

The works for the improvement of Vicksburg Harbor consist of the revetment of Delta Point, and of the dredging of a canal and basin in front of the city.

The object of revetting Delta Point was to prevent its further recession, which threatened to largely increase the width of the bar in front of the town. Between 1878 and 1884, 10,700 feet of bank were revetted. This work has not been repaired for several years. During the last low water an examination was made, which showed that the subaqueous mats are still in good condition, but several breaks were observed in the upper bank revetment, due to the rotting out of the brush. It is proposed, during the next working season, to repair these breaks, replacing the decayed brush with a layer of 10 inches of stone. Above the portion protected caving is slowly taking place. It will ultimately be necessary to further extend the revetment up the river, to prevent the flanking and destruction of the work constructed.

The work of dredging the canal and basin in front of the city was begun in 1887. In the project then adopted it was proposed to inclose the canal and basin by a dam constructed across Centennial Lake from the city to De Soto Island, and along the island parallel to the canal, for the purpose of limiting the flow of water into the basin during floods, and thus reducing the annual deposit of sediment. A permeable pile dike was first constructed along the axis of the dam, and as the dredging progressed the dredged material was deposited on both sides of the dike, so as ultimately to form a solid embankment of earth.

The canal was to have a bottom width of 75 feet, and slopes of 1 on 3 on the land side and 1 on 5 toward the river. The basin was to be 300 feet wide by 1,700 feet long, with slopes the same as the canal.

At the close of the last fiscal year the canal had been dredged to a depth of + 8 feet on the Vicksburg gauge, 954,514 cubic yards of material having been removed. Dredging was then in progress under a contract with the Alabama Dredging and Jetty Company, at 11.9 cents per cubic yard measured in scow, the cut being made to zero on the gauge.

Work was suspended September 7, due to the low stage of the river. A survey then made showed a fill averaging 5 feet through the canal, which had principally occurred during a flood of the June preceding.

Dredging was resumed February 8, 1892, and on May 15 one cut 40 feet wide had been again excavated through the canal to the zero of the gauge, and 3,000 linear feet of a second cut. The amount of material that has been excavated during the year has been 315,079 cubic yards.

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It has been proposed by Capt. J. H. Willard, Corps of Engineers, in charge of the improvement of the Yazoo River, to divert that river through Centennial Lake. Should that project be approved by Congress, a modification of the existing plans for the improvement of Vicksburg Harbor will be necessary.

The following report of Assistant Engineer H. St. L. Coppee gives in detail the work done during the season:

REPORT OF ASSISTANT ENGINEER H. ST. L. COPPEE.

Vicksburg Harbor, Mississippi.—At the time of submitting the last annual report the dredge *Herndon*, of the Alabama Dredging and Jetty Company, was at work in the harbor operating under the contract of January, 1891; the price being 11.9 cents, the requirement 4,000 cubic yards per day; the limit of contract December 31, 1891, and the amount of money available as per specifications $75,000, the Government reserving the right to reduce it to $60,000.

Up to May 1, 1891, the dredge had excavated on the contract as measured in scows 108,130 cubic yards. This excavation was to the zero plane, with the expectation that the slopes would slough down, leaving a cut to about the +3 foot plane; up to that time one cut 40 feet wide to zero had been taken out from Range 0 to 55 of canal, and one cut of outside slope from 0 to 10 (also in the canal).

The dredge *Herndon* continued to work in canal and basin to same depth until September 7, when, owing to low water, she was withdrawn; a long interval of low water occurring she was laid up for repairs, her tug and scows being sent to Mobile for use on other contracts. The contract time having elapsed, an extension was obtained and the dredge resumed work February 8, 1892.

At close of season's work September 7, 1891, the dredge had completed two channel cuts in canal and basin, to the zero of the gauge, and taken one cut from outside slope, all but 1,000 linear feet that had been abandoned on account of falling water. Since that date she has excavated one entire cut through canal to zero, and half of another, and is now continuing the same to the river.

The excavation measured in scows up to date on present contract is as follows:

1891.	Cubic yards.	1892.	Cubic yards.
March	49,532	February	31,568
April	58,598	March	44,732
May	55,870	April	58,030
June	43,170	May	13,545
July	51,213	Total to May 15	147,875
August	64,038	Total	479,079
September	8,783		
Total	331,204		

On the preceding contract (1890) the canal had been cut approximately to +8 feet on the gauge, and, as stated above, the purpose was to excavate the canal and basin on the present contract to an available depth of +3 feet on the gauge. In order to obtain this depth, as most of the slope was uncut, it was necessary to excavate to the zero plane to allow for sliding in of bank. During September (1891), after the dredge had been taken from harbor, the ranges were sounded throughout the entire canal and basin, careful levels being run over cross sections where it was impossible to sound, and the results plotted and compared with profiles of former years. These results indicated that a very considerable fill had taken place since cross sectioning in July, 1890, just after season's work, and in February, 1891. A report of these results was forwarded to your office October 14, 1891, which stated that "since 1888 up to the season of 1891, the fill in the harbor (canal and basin) had been comparatively slight, and could be accounted for by the slide of the sides of excavated channel and normal deposit for the aggregate rises during the seasons, as stated in reports and estimates submitted at the time." But the change in 1891 was in considerable excess of former experience. The report further states: "The excavation as determined by using ordinates between the bottom lines of February, 1891, and September, 1891, was 162,361 cubic yards, which is but about 50 per cent of the material actually removed by dredge as measured in scows, or about 60 per cent of the material measured in place."

Taking total cost of the season's work of 1891 as $39,413.28, we get the cost per cubic yard measured in situ=$39,413.28÷162,361=approximately 24 cents, or in other words, the excavated channel, instead of being to the +3 foot plane, as contemplated, and costing about 14 cents measured in situ, averages between the +5 and +6 foot plane, costing approximately 24 cents. Between the middle of June and July of 1891 there was a 10-foot rise in the river of a month's duration, and of

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sufficient height to take the water over a low place in the dam, creating a current north through canal and basin. This rise was notable for the great amount of sediment carried in suspension. As I stated in the report at the time, I am convinced that to this rise is due in great part the excessive fill, and until the dam at head of basin is raised to keep out currents from south end of lake at nearly flood stages, and the slopes are cut uniformly to the required angles to avoid sloughing, there will be a repetition of this filling process.

An estimate submitted June 5, 1891, of amount of material to be moved in order to cut canal and basin to the —5 and —10 foot planes, canal 75 feet wide at base, slopes 3 to 1 and 5 to 1, basin 300 feet base, same slopes and 1,600 feet long, based on measurements made just before that season's work, is as follows:

Plane.	In situ.	In scows.
Feet.	*Cubic yards.*	*Cubic yards.*
— 5	1,064,598	1,234,934
—10	1,552,488	1,800,886

Taking the 162,361 cubic yards in situ as amount moved from March to September, 1891, as measured after fill, and adding 16 per cent for scow measurement, we get 162,361 + 259,782 = 188,339 cubic yards in scows; increasing this by amount moved in 1892 to May 15, = 147,875 cubic yards, and amount that will probably be removed with funds remaining for present contract=about 100,000 cubic yards, we have 436,214 cubic yards, which, subtracted from amounts in above table, gives approximate amount of material to be removed from canal and basin in order to excavate to -5 and —10 feet planes; dimensions and slopes as above:

Plane.	In situ.	In scows.
	Cubic yards.	*Cubic yards.*
— 5-foot..	688,000	798,720
—10-foot..	1,173,619	1,364,672

As soon as the water falls sufficiently at end of present season, the canal and basin will be carefully cross-sectioned, and from the accurate soundings that are now being made (from dredge, for comparison) the amount of fill, and more detailed estimate will be obtained. I would respectfully call your attention, though, to the fact that there can be no freedom from abnormal deposit, and the project as contemplated at the beginning of the work in the harbor can never be successfully carried out unless some means is taken to build up the dam across the lake at head of basin. Every year material is dumped along the site of dam, while the water is at a high stage, but the shrinkage is such, and the duration of high water so limited, that but little has been accomplished. The crest of the dam now stands on an average at about the +25-foot stage, but should be built to the +45-foot.

It is proposed, during the balance of the season, to continue the second cut to zero through canal to river, and then use balance of money allotted for contract dredging in enlarging basin, thus obtaining an 80-foot channel (to zero) to city front, and a basin, probably 120 feet wide by 160 feet long, to same plane.

The amounts dredged since 1888, in canal and basin, are as follows:

Measured in scows:	Cubic yards.
1888	324,941
1890	465,573
1891	331,204
1892 to May 15	147,875
Total	1,269,593

In 1888 the price in situ was 18 cents; 1890 the price in scows was 10 and 12 cents; 1891 and 1892 the price in scows was 11.9 and 13.9 cents.

This represents a cut in canal 80 feet wide on base approximate to zero of gauge 6,000 feet long, with slopes averaging 3 to 1 from the original ground planes of + 12 at range 0, +20 at range 10, +23 at range 20, +26 at range 30, +28 at range 40, +30 at range 50, +30 at range 60. An average of about a 24-foot cut 80 feet wide at bottom, about 810,000 cubic yards in situ, 16 per cent for scows equals 939,600 cubic yards; adding basin cut to same plane, same slopes, 10 by 80 by 1,600 feet, we

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have about 70,000 cubic yards +16 per cent, 81,200, making total excavation canal and basin since 1888 equals 1,020,800 cubic yards; leaving approximately a fill of 248,793 cubic yards in four years, or about 60,000 yards per year. Last year the abnormal fill amounted to 100,000 cubic yards or more, making approximate fill during 1888, 1889 and 1890 equals 50,000 yards per year, or less.

The currents that have existed in canal since last report was submitted have corresponded very nearly with oscillation of river, except at highest stages, when water runs from Yazoo Swamp, through north end of Centennial Lake, causing a considerable flow south through canal, whether river is rising or falling. Up to June 11, 1891, the current was setting out of canal, but at that date commenced to run in, bringing a great quantity of drift and silt with it, increasing to one-half (½) foot per second, decreasing again to zero, July 15. From July 15 to 31 it was running out very slightly, and from July 31 to end of season stationary.

In 1892 it commenced to run in with rise of water during March and early April, but as soon as water rose sufficiently to overflow land above the old mouth of Yazoo (44½ feet) April 21 it set out again, and has continued in that direction to this time. The velocity averages as high as 1½ feet per second.

Menge dredge.—March 12, 1892, the Government dredge, *Menge*, was towed into the harbor, having been returned by officer of fourth district; her property was checked, and she was laid up until April 1, when a superintendent was placed on her, and a small crew employed to make the necessary repairs, preparatory to placing her in commission for work in the harbor. It was estimated that the repairs would cost about $1,500, and take a month to complete. The repairs consisted in a general overhauling of the machinery, the renewal and strengthening of the woodwork of the cranes, repairs of skiffs, yawls, in cleaning hull, calking, painting, etc. The repairs were practically completed in a month, and the dredge ready for work May 1, the cost of repairs being as follows:

April payroll	$658.25	Towing	$20.00
Subsistence	112.80	Iron castings	48.60
Traveling expenses	9.50	Barge hire	40.00
Lumber	132.76	Hauling	2.00
Hardware and oils, etc	283.95		
Horse hire	6.50	Total	1,335.36
Coal	21.00		

The cost of minor repairs being made during the present month (May), while waiting for tug and scows now at Greenville, will increase this amount to about the sum estimated. The estimate and list of expenditures does not include pay of assistant engineer in charge.

The dredge is in good shape and ready to go to work, as before stated, as soon as tug and scows are received.

The floating property at this point is as follows: Government, one ladder dredge *Menge*, one small barge, yawl, and skiffs; contractors, one clam-shell dredge *Herndon*, two scows, skiffs, etc., one tug *Col. Woodruff*. One United States inspector is employed on contractor's dredge.

DELTA POINT.

No change was noticed (before the water rose to flood height) in the revetment or bank at Delta Point. An examination was made December 7, 1891, in accordance with your instructions, and an estimate submitted for repairing some local breaks in the revetment, the cost being $5,000, but, as stated at the time, by another low-water season the deterioration may have increased to such an extent as to necessitate a very much greater expenditure. At the present time the water is 4 feet deep on the Delta Point bank. There has been no appreciable change in the river in the vicinity in the past year; the Delta and Kleinston banks are practically the same; the mouth of canal unchanged, and West Pass as before. The bar at mouth of Yazoo seems to be creeping down stream slowly, and Louisiana shore line, just opposite, caving away slowly.

LEVEES.

On the east bank of the river the levee line in the third district extends from opposite the mouth of White River to Eagle Lake, a distance by river of about 190 miles. The length of the levee line is about 167 miles. The allotments for these levees are made under the title: Levees, Lower Mississippi Levee District.

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On the west bank the levee system begins at Amos Bayou, about 17 miles north of Arkansas City, follows Cypress Creek to Lucca Landing on the Mississippi, and thence extends to the southern limit of the district. The length of the line is about 173 miles, of which 84.8 miles is in the State of Arkansas.

The local levee organizations which control the line, are the Desha County Levee Board, the Chicot County Levee Board and the Fifth Louisiana Levee District. Allotments have been made for levees on this bank under the title: Levees, Tensas Basin, Arkansas, and Levees, Tensas Basin, Louisiana, third district. Tabulated statements of the levees constructed by the United States under these allotments are appended.

In my last annual report a statement of yardage required in the various subdistricts, to raise the levees to a height 3 feet above the flood of 1890, was submitted. A material revision of that statement will be required to adjust it to the conditions of this year's flood; not only have the flood heights increased, but the flood surface has not remained parallel to its former position, the increase of flood heights being much greater from Greenville to Lake Providence, than at the extremities of the district. The local authorities in charge of the levees of the third district in Mississippi and Louisiana have submitted statements, at my request, of the work necessary this next season. These statements are appended.

To render the Tensas Basin, Arkansas, reasonably secure from a flood of the size of 1890 will require that at least 6,000,000 cubic yards of earth be added to the levee line, and that a levee be constructed from the boundary line between Lincoln and Desha counties, on the Arkansas River, to the mouth of Cypress Creek, to prevent the flow of water around the head of the system. The estimated cubic yardage in this levee is 2,231,000 cubic yards. From this year's flood it appears that perfect security will not be attained without extending this proposed levee to Pine Bluff.

LEVEES, LOWER MISSISSIPPI LEVEE DISTRICT.

The standard section adopted for levees in the Lower Mississippi Levee District is a width of crown of 8 feet, slopes one on three, and backed by a banquette 8 feet below the crown, with width of from 20 to 40 feet.

The standard height is 4 feet above the flood line of 1891.

The State authorities have made strenuous efforts during the last two years to strengthen their line, having erected in 1890-'91 1,492,973 cubic yards; in 1891-'92, 1,896,518 cubic yards, so that their levees have generally a width of crown of 8 feet, and are at least 2 feet above the flood line of 1890.

The levees under contract at the close of the last fiscal year were completed by August 1, 1891.

The allotment for levee construction in this district for 1891-'92 was $36,430.31. This sum was expended in strengthening the levee at Catfish Point (L. 423), and building loops to cover breaks in the line at Greenville (L. 478), Stella (L. 502), and Shipland (L. 543).

After the breaks in the levees at Catfish Point in 1890, the State authorities abandoned the old levee around the Point and built a short line across the neck. The flood of 1891, sweeping across the neck, scoured out the borrow pits and threatened to destroy the new levee.

To prevent this action three spur levees were built at right angles to the main levee, of lengths of 450, 300 and 500 feet, respectively, and the main line strengthened by building behind it a banquette 20 feet wide to a height 8 feet below the crown of the old levee. Thirty-six thousand eight hundred and thirty-two and eight-tenths cubic yards of earth were erected.

At Greenville the extensive caving during the flood of 1891, had destroyed the main line of levees. A temporary loop built during the flood, which had prevented a disastrous overflow, has been strengthened and brought up to the established grade. Fifty thousand five hundred and eighty-six cubic yards of earth were erected at this place.

At the Stella crevasse, due to the difficulties of locating a loop behind the break, it was decided to fill the hole scoured out by the flood and extend the levee across it. The levee was backed by a banquette 20 feet wide of the standard height, and contained 44,105 cubic yards.

At Shipland there has been rapid caving for several years, which breached the levee line during the low water of 1891 at two points. A levee 8,980 feet in length was constructed to cover these breaks. The balance of the allotment was expended on this levee, 156.548 cubic yards being erected by the Government. The levee was completed by the State authorities.

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LEVEES, TENSAS BASIN, ARKANSAS.

The levees of Arkansas are of much weaker section than those opposite them in Mississippi. The revenue of the local boards is barely sufficient to keep the levees in repair. What increased strength has been given to the line since 1890 has been mainly due to assistance rendered by the State of Louisiana and the United States. The prevailing type of levee through the district has a width of crown of 4 feet, and height about that of the flood line of 1890. There are many miles of levees, however, topped in 1890, where the width of crown at the height of that year's flood is but 2 feet. The levees constructed by the General Government and the State of Louisiana since then, have a width of crown of 8 feet, slopes one on three, and an elevation of 3 feet above the highest water. Those constructed by the United States at an earlier date have, generally, a width of crown of but 6 feet, and are from 1 to 2 feet lower.

During the last fiscal year the Desha County levee board has enlarged the levee in front of Arkansas City, erecting 19,235 cubic yards. The Chicot County levee board has constructed a levee at Luna (R 467), at Leland (R 483), and enlarged the levees at Bellevue Front (R 466) and at Sterling (R 515.) The Tensas levee board of Louisiana has enlarged the levee from Chicot (R 432) to Arkansas City, erecting 148,638 cubic yards.

At the close of the last fiscal year an extension of Lucca loop (R 428) was being constructed. This levee has been completed in contract time; 420,000 cubic yards being erected by the General Government, and 45,611 cubic yards by the Tensas Basin levee board of Louisiana.

With the funds available for this season's work the levee at Opossum Fork, opposite (R 427), has been enlarged, loops have been built at Sunnyside (R 491), and Cracraft (R 513), a spur constructed on Leland Short Line (R 470), and the enlargement of the levee below Lower Boggy Bayou (R 445) commenced.

During the flood of 1890 the Opossum Fork levee required topping, to prevent the water flowing over it. By this season's enlargement its height has been increased 4 feet, with an exterior slope of one on four; and a banquette has been constructed behind it 30 feet wide to a height 10 feet below the crown of the levee. The enlargement contains 99,949 cubic yards; its length is 4,040 feet.

In the loop at Sunnyside 117,973 cubic yards of earth were placed. Its length is 6,577 feet. At the bayou at the lower end of the levee, the slopes were given an inclination of one on four above the water surface; below the water line the earth assumed a slope of about one on six.

At Cracraft a loop 4,115 feet long and containing 43,383.6 cubic yards, was erected to cover a break in the levee line caused by caving banks.

The spur constructed on Leland Short Line contained 8,072 cubic yards, and was built to prevent a scouring at the base of the levee and in the borrow pits by the rapid flow of water across Point Chicot during floods.

Arrangements had been made to expend the balance of the allotment in enlarging the levee south of Lower Boggy Bayou. The contractor had erected about 1,000 cubic yards, when he was compelled to suspend operations by a rise of the river which filled the borrow pits.

LEVEES, TENSAS BASIN, LOUISIANA.

Since the flood of 1890 the fifth Louisiana Levee district has erected 1,558,758 cubic yards in the portion of the Tensas Basin, Louisiana, included in the third district. This work has greatly strengthened the levee line, about 58 miles being at a height of at least 3 feet above the flood line of that year. There are, however, several miles of dangerously low levees in the subdistrict, and a number of large levees are threatened with destruction by the caving of the river banks.

With this year's allotment of $70,040.09, a levee was constructed at Illawara (R 562), containing 349,241 cubic yards, to replace a large levee threatened with destruction by caving banks.

HIGH-WATER PROTECTION OF LEVEES.

For the high-water protection of levees this season there had been reserved 5 per cent of the allotments for levees in the various subdistricts for the lower Mississippi levee district:

For the Lower Mississippi levee district	$1,821.52
For the Tensas Basin, Arkansas	2,250.00
For the Tensas Basin, Louisiana	3,502.00

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It being evident that with such a small supply of funds no effective high-water fight could be maintained; when the river began to overflow its banks the local authorities were notified that such limited assistance as could be rendered with the funds available, would be given in supplying material for use at such threatened points as should be designated.

As the flood assumed alarming proportions, $5,000 was allotted by the Mississippi River Commission, approved by the Secretary of War, for high-water protection of the levees of Tensas Basin, Arkansas, and forces were organized by the General Government in that subdistrict. This allotment was quickly followed by others, until the available funds for high-water protection of Tensas Basin, Arkansas, were $20,250; for lower Mississippi levee district, $8,821.52; for Tensas Basin, Louisiana, $6,500.

In the lower Mississippi levee district the assistance rendered by the United States has principally consisted in supplying material. In the Tensas Basin, Arkansas, the general charge of the entire line of levees has been assumed, the local authorities supplementing the efforts of the Government with such assistance as they could render. The funds expended in the Tensas Basin, Louisiana, were principally employed in raising and strengthening the weakest portions of the line at Wilsons Point (R 432); Lake Providence (R 542), and Villa Vista, (R 574).

By the joint efforts of the United States and the local authorities the levees were held until from Greenville to Lake Providence the river had risen 6 inches higher than ever before recorded. A crevasse then occurred at Brooks Mill (R. 506) (May 9), followed by a break in the Panther Forest levee (R. 451), on May 13, the Greenville gauge reading 44.15 feet at the time. These breaks lowered the flood height below them, and no breaks were reported until May 25, when a crevasse occurred at Leland (R. 484) the Greenville gauge reading 44.2.

No breaks have yet occurred in the levees of Mississippi or Louisiana in the third district.

The Brooks Mill crevasse was gauged May 13; 35,000 cubic feet per second was flowing through it. Its width was 670 feet. No effort has been made to hold the ends, and while the levee is caving away at the rate of about 10 feet per day, the crevasse is widening slowly, due to the break occurring at a reëntrant angle of the levee line.

A measurement of the flow through the Panther Forest crevasse was made May 17, and found to be about 72,000 cubic feet per second. The crevasse had widened to 1,023 feet; May 25 a width of 1,400 feet was reported.

In addition to the water flowing through these crevasses, there is a large overflow from the Arkansas River, around the head of the levee system. A measurement of the discharge across the railroad track from Arkansas City to Pine Bluff is being made, as a large flow is reported into Bayou Bartholomew, below the latter place. The Tensas Basin, Arkansas, appears to be greatly flooded, with the exception of the high ground in the vicinity of Lake Chicot, and from Grand Lake to the Louisiana State line. The effects of the flood are also beginning to be felt along the bayous in Louisiana, which extend into Arkansas.

The crevasse at Brooks Mill occurred in a levee of poor material, which became so saturated with water as to be unable to withstand the pressure, and yielded by sloughing. At Panther Forest, in an underlying layer of quicksand, the water attained such a head as to break through a layer of buckshot behind the levee; the quicksand was quickly washed out and the levee sunk into the cavity. A similar accident occurred previously near this locality, but the overlying mass sunk in such a manner as to cut off the flow below, and by covering the submerged mass with bagging on which was piled sacks filled with earth the levee was brought to the water surface again, and a crevasse was prevented.

Forty-four feet on the Greenville gauge is the limit to which the levees of Tensas Basin, Arkansas, in their existing condition may be expected to withstand the action of a flood. When the crevasses occurred, at numerous points were similar conditions developing as caused the breaks. For over 40 miles the crown of the levee was but a few inches above the water surface. Waves caused by wind storms break over these low levees and saturate the interior slopes. Material freshly placed is soon converted into mud. Even when the levee is well sodded the resisting power of earth must be largely reduced by this saturation, and where the crown has a width of from 2 to 4 feet, as is usual in these localities, there is little resisting power to spare.

THE FLOOD OF 1892.

Through the third district, from Arkansas City to Lake Providence, the river has attained a height never before recorded, and at the date of this report is still rising.

In the following table the maximum heights at the gauge stations in the districts

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during the floods of 1882, 1890, 1891, and of 1892 to May 27 are given, together with those of Helena and Cairo:

Stations.	1882.	1890.	1891.	1892.
White River	48.40	50.4	47.7	....
Arkansas City	47.00	49.5	48.2	49.6
Greenville	41.68	43.45	43.25	44.2
Lake Providence	38.32	41.0	41.1	41.65
Vicksburg	48.75	49.0	48.1	48.4
Cairo	51.87	48.8	46.2	48.2
Helena	47.2	47.7	44.7	45.8

From Greenville to Lake Providence this year's flood has exceeded that of 1890 by about seven-tenths of a foot, while from Arkansas City to Lake Providence it has exceeded that of 1882 by over 2¼ feet. This increased height of the flood line in the Third district can be attributed only to the influence of levees. At Helena this year's gauge reading is 1.9 feet below that of 1890, and, while there have been abnormal floods in both the White and Arkansas rivers, the heights attained are not due to their action, except at Arkansas City. On May 9, when the Brooks Mill break occurred, the maximum reading of the Lake Providence gauge was recorded; on May 13 the reading of the Greenville gauge was 44.15, and on May 16 that at Vicksburg attained its maximum. The great floods of the White and Arkansas rivers have reached the Mississippi since these dates, and, while they have raised the river at Arkansas City five-tenths of a foot, the extra water has, to date, been carried off by the crevasses and by the overflow into the Tensas Basin from the head of the levee system to Pine Bluff, Ark.

A table is also submitted giving the maximum measured river discharges at the latitude of Lake Providence, together with the estimated flow by that latitude, when escape through crevasses was included:

	Cubic feet per second.			
	1882.	1890.	1891.	1892.
Measured discharges	1,057,000	1,288,000	1,346,000	1,433,000
Estimated flow	2,000,000	1,720,000	1,400,000	....

This table shows what has been accomplished by the levee construction since 1882, at least 35 per cent more water during floods is at present retained between the levee lines. But it is also evident that the height of levees must be largely increased if the country is to be protected against a flood of the size of that of 1882.

An increase of discharge of 376,000 cubic feet per second has been accompanied at Lake Providence by an increase of flood height of 3.3 feet.

SURVEYS, GAUGES, AND OBSERVATIONS.

The gauges at Greenville, Arkansas City, Clarendon, and Yazoo City, which have been under the charge of this office, have been daily read. The bulletin boards at Arkansas City and Greenville have been repaired.

Surveys were made at Ashbrook Neck, Greenville, and Louisiana Bend while the works were in progress.

In October an hydrographic survey of Lake Providence Reach was made, and also in the vicinity of Pecan Grove, to determine changes due to the Raleigh crevasse of 1890.

Four sets of low-water discharge observations were taken at Wilsons Point in October, and two parties are at present engaged in measuring the high-water discharge; one at Wilsons Point and the second at Arkansas City.

The discrepancies in the discharge observations at Wilsons Point and Arkansas City noted last season are still more marked this year. Careful observations are being taken to determine, if possible, the cause of these discrepancies.

A detailed description of the operations of the survey party will be found in the accompanying report of Assistant Engineer Hider.

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REPORT OF ASSISTANT ENGINEER ARTHUR HIDER ON SURVEYS, GAUGES, AND OBSERVATIONS, THIRD DISTRICT.

The force employed on this work was as follows:

Date.	Number.	Nature of work.
1891.		
June	6	Preparing maps for annual report and reducing discharge measurements.
July	8	Reducing levee locations in Arkansas to uniform scale and making profiles of new levees.
August	2	Making tracings of levee locations in Arkansas and preparing a skeleton map of Lake Providence Reach for annual report.
September	2	Locating new levees at Greenville, Stella Crevassé, and Shipland, Miss.; preparing profiles and approximate estimates.
October	15	Low-water survey of Lake Providence Reach and of the river in the vicinity of the Raleigh Crevasse, La. Low-water discharge at Wilsons Point.
November	10	Continuation of low-water survey and discharge observations at Wilsons Point, and taking soundings along Greenville Front.
December	3	Plotting survey of Lake Providence Reach and in the vicinity of Raleigh.
1892.		
January	5	Plotting and computing low-water discharge and velocity observations at Wilsons Point, and in Louisiana Bend.
February	4	Checking P. B. marks in the vicinity of Greenville and making progress sketches.
March	4	Plotting new locations of levees in the third district, on charts, and computations.
April	17	Discharge observations at Arkansas City and Wilsons Point.

The surveys have been under the charge of Mr. W. P. Richards until November 1, 1891; since that time the party has been under the charge of Thomas C. J. Baily, jr.

Fieldwork.—A party was organized October 5 to make the annual low-water survey of L. P. Reach. The survey began at Carolina Landing and extended to Point Lookout. A survey of the river was also made in the vicinity of Pecan Grove, La., in order to determine changes due to the Raleigh crevasse of March, 1890. One hundred ranges were put up and sounded, 30 miles of caving banks located, and 60 angles of the triangular system of Lake Providence Reach measured.

Low-water discharge was measured, four sets of measurements being taken at Wilsons Point and one in Louisiana Bend; also three sets of velocity observations were taken to locate point of maximum velocity at low water in Louisiana Bend.

A survey was made along Greenville Front, seventy sections being sounded out to and beyond low water. The party was disbanded November 22, 1891.

On April 11, 1892, a party was organized to measure the high-water discharge at Wilsons Point, and on April 18 another party was put in the field to measure the discharge at Arkansas City. These parties are still taking observations.

Office work.—From June until November and from December until April, the office force was employed on the following work:

Maps and tracings.—Arkansas levees, Tensas Front, Lake Providence Reach, vicinity of Raleigh Crevasse, construction works at Ashbrook Neck, Greenville Harbor, and Louisiana Bend (20 sheets).

Comparative sections have been selected and plotted in Lake Providence Reach, as determined by the low-water surveys of 1882, 1883, 1884, 1886, 1888, 1890, 1891; computations made also for similar sections above Greenville. The geographical coördinates of twenty stations have been determined, and recent levees placed on six sets of lithographed charts.

High-water discharge, Wilsons Point.—On April 16, the high-water observations were begun. Twenty-eight measurements have been made. The section adopted is the same as used in 1891, meter stations 300 feet apart.

The survey steamer *Meter* is used in the work and is kept as near as possible on the intersection of two ranges, marking the meter station during the time of observation, the revolutions of the meter being counted consecutively and recorded at intervals of one minute. Each station is occupied for five minutes or more, until, in the judgment of the chief of party, an average velocity has been registered. Great care is taken that the steamboat has the same position, with reference to the cross-range at the end of the observation, that it had at the beginning.

Observations taken on this section, to determine the movement of the steamboat while occupying the meter stations, demonstrates the fact that the lateral drift of the steamboat with a skillful pilot, while the meter observation is being taken, is but a small source of error in comparison to that introduced, when at the end of the counting on a station, the steamboat is ahead or back of its initial point.

This section is free from "boils" and eddies, and but little difficulty is experi-

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enced in keeping the steamboat in the desired position, and, consequently, is favorable for meter work.

The current meter used for low-water observations was a Price No. 5, an old instrument that gave but indifferent ratings. For the high-water discharge, Price No. 38 (new) is being used with very satisfactory results. Thus far three ratings have been obtained, one taken from the steamboat in Old River, Louisiana, and two from a skiff near Wilsons Point. The rating taken in Old River was in considerable current; those near Wilsons Point in dead water; the results are practically identical.

The current meter is attached to a 225-pound lead, submerged to $\frac{6}{10}$ the depth, revolutions counted by means of a telegraph sounder in a circuit generated by four Le Clanche cells; soundings being taken with a 20-pound lead on a $\frac{3}{8}$-inch cotton line, each sounding being located by a transit angle on shore.

On May 19, the meter observations were checked by subsurface floats submerged to $\frac{6}{10}$ of the depth, and the mean velocity as given by the meter found to be 2 per cent greater than that given by the floats.

These float observations also showed that the current is nearly at right angles to the discharge section and that comparatively few "boils" existed.

The crevasse at Brooks Mill (506 R.), which took place May 9, was measured on May 13, and was found to be 670 feet wide, with a discharge of 35,000 cubic feet per second and widening very slowly.

The results of field computations, as made by Mr. T. C. J. Baily, chief of the survey party for the low-water discharge of October and November, 1891, and of the high-water discharges, April 16 to May 19, 1892, are given below:

Low-water discharge measurements, Lake Providence Reach, 1891.

Date.	Wilsons Point gauge.	Width.	Depth.	Mean velocity per second.	Area.	Discharge per second.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Cubic feet.*
October 16, 1891	1.06	3,296	20.7	1.960	68,244	133,727
October 17, 1891	0.92	3,296	20.8	1.956	68,444	133,892
October 19, 1891	0.72	1,587	42.8	1.963	67,912	133,917
October 20, 1891	0.76	3,296	19.6	1.929	68,971	133,050
November 12, 1891	—0.04	3,296	19.3	1.841	63,959	117,187

Measurements of October 16, 17, 20, and November 12, 1891, were taken at Wilsons Point; that of October 19, at Louisiana Bend.

Approximate results of discharge measurements at Wilsons Point.

Date.	Gauge.	Width.	Mean depth.	Mean velocity per second.	Water area.	Scour.	Fill.	River discharge per second.	Discharge over bank per second.	Total discharge per second.
1892.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Cubic feet.*	*Cu. ft.*	*Cubic feet.*
Apr. 16	35.60	3,925	49.2	5.611	193,400	....	....	1,086,200	....	1,086,200
18	36.55	3,931	50.2	5.629	197,300	....	100	1,110,700	....	1,110,700
19	36.78	3,932	50.7	5.835	199,300	1,200	....	1,162,900	....	1,162,900
20	37.20	3,934	51.7	5.972	203,600	2,700	....	1,215,800	....	1,215,800
21	37.45	3,935	52.2	5.854	205,300	600	....	1,202,000	....	1,202,000
22	37.75	3,937	52.0	5.811	204,800	....	1,700	1,190,300	2,500	1,192,800
23	38.08	3,938	53.7	6.105	211,700	5,700	....	1,292,200	3,300	1,295,500
25	38.68	3,941	54.7	6.084	215,500	1,500	....	1,311,400	4,100	1,315,500
26	38.98	3,943	54.8	6.035	216,300	....	300	1,305,300	5,300	1,310,600
27	39.18	3,944	53.9	6.324	212,600	....	4,600	1,344,500	6,500	1,351,000
28	39.36	3,945	54.8	6.399	216,400	....	7,000	1,384,600	7,700	1,392,300
29	39.67	3,946	56.4	6.233	223,300	5,700	....	1,391,700	8,900	1,400,600
30	39.84	3,946	56.1	6.014	221,500	....	1,400	1,332,000	10,100	1,400,600
May 2	40.12	3,946	56.0	6.011	221,100	....	2,000	1,328,900	12,400	1,341,300
3	40.22	3,946	56.0	6.416	221,000	....	100	1,421,000	12,400	1,433,400
4	40.32	3,946	56.7	5.627	223,900	2,500	....	1,259,700	12,400	1,272,100
5	40.46	3,946	55.9	6.083	220,800	....	3,700	1,343,100	12,300	1,355,400
6	40.62	3,946	56.1	5.985	220,200	....	1,300	1,317,600	12,300	1,329,900
7	40.73	3,946	56.9	6.054	224,600	4,000	....	1,359,600	12,300	1,371,900
9	41.00	3,946	57.1	6.086	225,200	....	400	1,370,800	12,300	1,383,100
10	40.84	3,946	56.8	6.257	224,400	....	100	1,403,900	12,200	*1,416,100
11	40.75	3,946	56.8	5.872	224,200	....	....	1,316,300	12,200	*1,328,500
12	40.82	3,946	57.0	5.994	225,100	700	....	1,351,300	12,200	†1,363,500
14	41.00	3,946	57.5	5.596	226,900	1,100	....	1,269,600	12,200	†1,281,700
16	40.80	3,946	56.8	5.595	224,100	....	2,000	1,253,900	12,200	†1,266,100
18	40.85	3,946	57.5	5.631	227,100	2,600	....	1,278,800	12,200	†1,291,000
19	40.75	3,946	57.5	5.619	226,800	100	....	1,274,400	12,200	†1,286,600

* Crevasse Brook's Mill May 9.   † May 13, 1892, Panther Forest Crevasse

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High-water discharge, Arkansas City, Arkansas.—The same discharge section as that adopted in 1891 was used. The snag boat *Thos. B. Florence* was employed for meter work, and similar methods employed as at Wilsons Point station. Twenty-three complete measurements have been made. The first discharge obtained was April 23. Four observations have been taken to determine the direction of current crossing the discharge section; two to locate the steamboat, and to determine change of position while meter stations were being occupied. Four ratings of new current meter No. 39 obtained, and one complete discharge measured by means of double floats. The crevasse at Panther Forest, which took place May 13, was measured on the 17th; the width was found to be 1,020 feet and discharge 72,000 cubic feet per second. This crevasse is enlarging rapidly.

Below is given the results of the field computations of the discharge measurements to May 21, as made by Mr. C. H. Miller, chief of the party.

Results of discharge measurements at Arkansas City, Ark.

Date.	Gauge reading.	Difference.	Area.	Scour.	Fill.	River discharge per second.	Over banks per second.	Total per second.	Mean velocity per second.	Mean depth.
	Feet.	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*	*Cubic feet.*	*Cu. ft.*	*Cubic feet.*	*Feet.*	*Feet.*
Apr. 23	46.35	....	242,283	....	....	1,457,567	8,000	1,477,767	6.091	70.4
25	46.90	+.55	239,538	....	2,745	1,403,807	3,271	1,407,078	5.860	69.6
26	47.07	+.17	246,626	7,088	....	1,632,837	3,765	1,636,602	6.620	71.4
27	47.25	+.18	245,959	....	667	1,626,867	4,259	1,631,126	6.610	70.9
28	47.45	+.20	248,733	2,774	....	1,556.446	4,753	1,561,199	6.257	71.9
29	47.61	+.16	251,009	2,276	....	1,578,239	5,247	1,583,486	6.288	72.5
30	47.78	+.17	251,290	281	....	1,611,626	5,741	1,617,367	6.413	71.6
May 2	47.96	+.18	246,406	....	4,884	1,654,867	6,729	1,661,596	6.725	71.2
3	48.02	+.06	247,319	913	....	1,562,137	7,223	1,569,360	6.316	71.4
4	48.10	+.08	246,337	....	982	1,765,249	7,363	1,772,612	7.166	71.2
4	48.10	+.08	246,337	....	....	1,773,885	7,363	1,781,248	7.201	71.2
5	48.25	+.15	247,613	1,276	....	1,614,515	7,504	1,622,019	6.520	71.5
6	48.33	+.08	248,357	744	....	1,684,252	7,644	1,691,896	6.782	71.7
7	48.55	+.22	247,178	....	1,179	1,646,040	7,784	1,653,824	6.659	71.4
9	48.75	+.20	248,329	1,151	....	1,681,488	8,066	1,689,554	6.771	71.7
10	48.80	+.05	246,304	....	2,025	1,621,672	8,106	1,629,778	6.584	71.2
11	48.88	+.08	250,386	4,082	....	1,531,102	8,347	1,539,449	6.115	72.0
12	48.95	+.07	249,272	....	1,114	1,583,438	8,433	1,591,871	6.352	72.0
13	49.14	+.19	247,714	....	1,558	1,492,361	8,519	1,500,880	6.025	71.5
14	49.14	....	243,301	....	4,413	1,435,479	8,605	1,444,084	5.900	70.3
16	49.10	—.04	251,224	7,923	....	1,442,498	8,777	1,451,275	5.742	71.6
19	49.15	+.05	251,528	304	....	1,493,266	9,034	1,502,300	5.987	71.6
21	49.27	+.12	246,340	....	5,188	1,421,272	9,184	1,430,456	5.770	71.2

NOTE.—Very high wind on May 4. Observations taken in A. M. and P. M. Observation of 16th was taken by means of double floats.

A comparison of the results at Arkansas City and Wilsons Point, making allowance for the two crevasses on the right bank between the two stations, shows an average excess of about 210,000 cubic feet per second in the Arkansas City discharge.

As the measurements have been taken with equal care at both places, some other cause besides errors of observation must be looked for to account for this large difference. The cause, it is believed, will be found among the following:

(1) The river section at Arkansas City is comparatively narrow, being about 500 feet less than that at Wilsons Point. The increase of section due to scour during the time the observations were taken at Arkansas City was 4,057 square feet, while at Wilsons Point there was a filling up of the section of 4,700 square feet. This scouring out of bottom causes upward "boils" and eddies, the meter consequently registering too high velocities to give the discharge accurately.

(2) The effect of reservoir capacity of 100 miles of river between the two stations.

(3) The increased velocity registered, due to lateral drift of the steamboat while the meter stations were occupied; as on account of "boils" and surface eddies it is much more difficult to keep in position than at Wilsons Point station.

Observations are now being made at both stations by using double floats to check the meter results, and by locating the path of the steamboat while observations are taken to eliminate what errors occur from these causes. These corrections will be made in the final computations.

CARE OF FLEET AND REPAIRS TO PLANT.

The floating plant and other property, when not in use, has been collected and cared for about 1 mile below Greenville, Miss. One barge and the old dry dock have

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been lost during the year, and six pile-drivers dismantled. Ten model barges have been repaired by the general service; nine barges and two quarter boats have been docked and repaired at the fleet; thirty-one barges, ten quarter boats, five mat boats, and two dump scows have been calked and repaired above light water, and minor repairs made to nearly all the plant. Ten new barges (120 by 28 by 6 feet) and a floating dock have been built by contract and received.

The cost of the barges was $2,475 delivered below the falls of the Ohio River at Louisville. The floating dock is 185 by 50 feet. Its contract price was $19,510, without pumping machinery, delivered at Louisville. The pumps from the old dock, and two engines from condemned pile-drivers have been placed upon her, and work satisfactorily.

There is appended a list of floating property, giving its condition, and an estimate of the cost of making such repairs as are needed for next season's work. A large number of the boats have been in service over ten years, and are requiring each year an increased expenditure to render them serviceable. To work with three revetment parties, as was done last season, requires a large addition to the plant of the Third district. At least forty barges and two towboats should be added to the fleet.

There are also appended to this report abstracts of proposals for levees and material, and financial statements, and it is accompanied by maps of the revetment work constructed at Ashbrook Neck, Greenville, Louisiana Bend, and of Lake Providence Reach.

Respectfully submitted.

C. McD. TOWNSEND,
Capt. of Engineers.

Col. C. B. COMSTOCK,
Corps of Engineers, Brvt. Brig. Gen., U. S. A.,
President Mississippi River Commission.

Plant, Third district.

Description.	Pieces.	Condition.
Headquarter boat	1	Good.
Survey quarter boat	1	Do.
Mechanics' quarter boat	1	Do.
Fleet quarter boat	1	Bad. Needs new hull and other repairs.
Office quarter boat	2	Fair.
Laborer's quarter boat	7	Bad. Require new hulls.
Weaving barges	6	Bad. Will last another season with ordinary repairs.
Barges:		
Model (120 by 28 feet)	10	Good.
Square (120 by 28 feet)	10	Good. Built last season.
Square (120 by 26 feet)	4	Good.
Square (120 by 26 feet)	3	Bad. Require new gunwales and deck.
Square (100 by 25 feet)	7	Good.
Square (100 by 25 feet)	4	Bad. Require new gunwales and deck.
Square (75 by 15 feet)	5	Bad.
Mooring (120 by 26 feet)	2	Bad. Need new deck and deck frames.
Square (100 by 20 feet)	8	Do.
Pile-drivers	6	Fair.
Grader, hydraulic:		
No. 3	1	Bad. Needs new sides, deck and deck frame, and repairs to machinery.
No. 1	1	Fair. Needs repairs to hull below water line, and calking.
No. 77	1	Good.
Dump scows (100 by 25 feet)	2	Fair.
Floating dock (185 by 50 feet)	1	Good. Built last season.
Steam boats:		
Osceola	1	Bad. Needs new cylinder timbers and repairs to hull and cabin.
Vidalia	1	Bad. Requires new cylinders and repairs to hull, cabin, and machinery.
Meter	1	Fair. Ordinary repairs.
Steam tug Parker	1	Do.
Yawls	6	Bad.
Skiffs	36	Do.
Pontoon 1, end dock 1, and flats 7	9	Fair.
Machine shop	1	Bad. Needs new gunwales and calking.
Carpenter shop	1	Bad. Not worth repairing.

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Estimated cost of repairs.

Moving cabins from the hulls of 8 laborers' quarter boats to other boats and remodeling cabins, 8 boats, at $1,250 each	$10,000
Sheathing gunwales and other repairs on 6 mattress boats, to render them serviceable for next season's work, 6 boats, at $250 each	1,500
Rebuilding sides and decks of 7 square barges, at $1,350 each	9,450
Repairs to 5 small barges, at $1,250 each	750
Repairing with new deck frames and deck, 2 mooring barges, at $550 each	1,100
Repairs to Grader No. 1 (on hull)	550
Rebuilding sides, new deck frame, and deck, and replacing machinery Grader No. 3	2,000
Repairing 8 small barges, at $250 each	2,000
Repairing steamer *Osceola*, new cylinder timbers, and repairs to hull and cabin	3,500
Repairing steamer *Vidalia*, hull, cabin, machinery, and new cylinders	3,000
New gunwales and repairs to deck frame and deck of machine shop	2,500
For ordinary repairs to other parts of the plant during the season not enumerated above	10,000
	46,350

Cost of levees in Arkansas, third district, built and enlarged by the United States, from 1882 to May 31, 1892.

Year built.	Name of levee.	Built by—	Cubic yards.	Cost, including extra work.	Location on inch to mile map.
1882–'91	(See annual report for 1891)		2,162,762	$482,547.17	
	Expended for high-water protection and engineering expenses.			102,535.91	
1891	Brooksfield	Joseph M. Whitehill	16,575.2	4,143.80	R Op. 425
	Lucca loop	do	420,000	76,650.00	R Op. 428
	Sunnyside	Sunnyside Company	42,181	6,748.96	R. 490
	Luna levee	Robt. E. Craig	32,205.5	7,007.27	R. 467
	Columbia	do	17,453.2	3,272.47	R. 469
	Leland	do	45,127.6	7,897.33	R. 470
	Boggy Bayou	A. R. Fudge	92,923.3	23,953.32	R Op. 426
	Opossum Fork	Joseph M. Whitehill	99,948.7	24,987.18	R Op. 427
	Sunnyside extension	Campbell & Garigan	117,973.5	16,221.34	R. 491
	Cracraft	J. C. Hodge	43,383.6	54,222.95	R. 513
1892	Spur of Leland levee	do	8,072.4	1,291.58	R. 470
Expended for high-water protection and engineering expenses January 1, 1891, to May 31, 1892.				36,783.17	
Total yardage to May 31, 1892			3,098,606		
Total cost to May 31, 1892				799,462.45	

Cost of levees in Mississippi, third district, built and enlarged by the United States, from 1882 to May 31, 1892.

Year built.	Name of levee.	Built by—	Cubic yards.	Cost, including extra work.	Location on inch to mile map.
1882–'91	(See annual report for 1891)		1,672,619.3	$398,630.45	
	For protection and engineering expenses (see annual report, 1891).			95,175.57	
1891	Clover Hill	Timothy Sullivan	39,168.5	8,225.38	L 534
	Longwood	do	61,824.6	18,547.00	L 502
	Skipwith (Upper)	Carey & Mims	42,752	10,688.00	L 528
	Skipwith (Lower)	W. H. Pollock	23,776	5,034.21	L 529
	Offuts Front	Harvey & Scott	358,717.2	101,717.00	L 445–478
	Port Anderson to Offuts	do	41,151.7	9,061.53	L 443–444
	Timberlake to Port Anderson.	do	51,153	12,296.98	L 441–443
	Protection levee near Greenville.	Withers & Montgomery.	15,863	4,441.74	L 479
	Greenville	Ware & Donovan	50,586.6	6,715.49	L 478
	Stella crevasse	Timothy Sullivan	44,105.	8,159.42	L 503
	Shipland	T. W. Scott & Co	156.548	19,411.95	L 543
	Ashbrook Neck	A. A. Arnold & Co	56,676.3	9,559.52	L 446
	Catfish Point	John A. Ware	36,832.8	5,156.59	L 423
Expended for high-water protection and engineering expenses, January 1, 1891, to May 31, 1892.				25,494.15	
Total yardage			2,651,774.0		
Total cost				738,314.98	

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Cost of levees in Louisiana, third district, built and enlarged by the United States, from 1882 to May 31, 1892.

Year built.	Name of levee.	Built by—	Cubic yards.	Cost, including extra work.	Location on inch to mile map.
1882-'91	(See annual report for 1891)		1,299,398.6	$288,856.78	
	Expended for high-water protection and engineering expenses. (See annual report, 1891.)			96,910.67	
1891	Elton	John Scott & Son	345,918.2	97,582.43	R 542
	Illawara	J. E. Mulcahy and J. E. Sullivan.	349,241	56,577.04	R 562
	Expended high-water protection and engineering expenses, January 1, 1891, to May 31, 1892.			23,367.90	
	Total yardage to May 31, 1892		1,994,557.8		
	Total cost to May 31, 1892			563,294.82	

Estimate of work to be done in the Mississippi levee district during the season of 1892-'93.

	Yards.
From Hughes to Catfish Point:	
2,900-2,960	68,600
2,800-2,900	103,100
2,700-2,800	71,100
2,600-2,700	57,100
2,500-2,600	61,400
2,400-2,500	87,600
2,300-2,400	75,400
2,150-2,300	101,500
Total	625,800
From Catfish Point to Timberlake:	
Catfish Point levee	115,200
3,400-3,500	68,200
3,500-3,600	63,300
3,600-3,700	70,000
3,700-3,800	70,000
3,800-3,900	74,800
3,900-3,970	32,900
Total	494,400
Upper Bolivar:	
Waxhaw levee	90,000
Stokes Front	125,800
Above Rosedale	20,000
Beulah to Clarks	49,000
Total	284,800

The whole amount of work herein estimated, consisting entirely of enlargement work, is 1,405,000 cubic yards. It is not at present expected that it will be necessary to build any new levees.

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List of levees in Tensas Basin, Louisiana, third United States district, which require to be built and enlarged.

[Prepared in office board of State engineers, at request of Capt. C. McD. Townsend, Corps of Engineers, U. S. Army, April 23, 1892.]

Stretch of levee line.			Top of levee referred to high water, 1890. Length in feet.					Total length of levee line between points.
Descriptive name.	Miles below Cairo.	Parish.	Below high water.	Between 0 and 1 foot above high water.	Between 1 and 2 feet above high water.	Between 2 and 3 feet above high water.	Between 3 feet and above high water.	
								Feet.
State line to Pilchers Point	520 to 522½	East Carroll	....	1,500	13,800	3,200	....	18,500
Wilson Point to Donna Vista	531½ to 535½	....do	7,500	5,300	3,900	......	....	16,700
Longwood to Elton levee	538 to 539½	....do	....	....	....	3,300	3,700	7,000
Elton levée to Dessona	542 to 544	....do	....	....	5,200	13,200	....	18,400
Illawara to Pecan Grove	563½ to 564½	....do	....	......	....	....	4,900	4,900
Pecan Grove to Henderson	572½ to 573½	....do	....	400	1,500	3,800	....	5,700
Henderson to Mascot	573½ to 575½	....do	2,400	....	....	....	8,600	11,000
Mascot to Omega	575½ to 578½	Madison	300	3,300	8,300	2,100	....	14,000
Millikens Bend to Cabin Teele.	582 to 585½	....do	1,100	2,000	2,800	1,900	15,200	23,000
Cabin Teele to Youngs Point	585½ to 593½	....do	200	3,200	12,600	13,000	9,800	38,800
Youngs Point to Elcho	593½ to 594	....do	....	....	1,000	1,300	1,700	4,000
Elcho to Biggs	594 to 602½	....do	....	1,800	3,875	18,800	10,100	34,575
Biggs to Bedford	603½ to 606¾	....do	....	1,500	6,500	7,100	5,000	20,100
			11,500	19,000	59,475	67,700	59,000	216,675

REMARKS.

State line to Pilcher Point: This line now under contract by State of Louisiana.

Wilson Point to Donna Vista: This line has 12 to 15 feet crown, and a ridge on river edge equal to high water, 1890.

Elton levee to Dessona: Upper end of this line threatened by caving bank.

Illawara to Pecan Grove: Threatened by caving bank within few years.

Pecan Grove to Henderson: Small levee, with average crown of 8 feet.

Henderson to Mascot: Lower end threatened by caving bank; now under contract by fifth Louisiana levee district.

Mascot to Omega: Upper end threatened by caving bank.

Millikens Bend to Cabin Teele: Threatened by caving bank; new levee containing about 465,000 cubic yards will be required here the coming season.

Youngs Point to Elcho: New levee will be required here the coming season.

Biggs to Bedford: Portions of this line threatened by caving bank.

The remainder of the line in the third United States district, Louisiana, aggregating about 47 miles in detached stretches, stand, at a grade equal to 3 feet above the high water of 1890; but in most cases it also requires enlargement of section and general repair. The levee reported as below high water of 1890 has a ridge on river edge of crown up to height of said high water.

Abstract of proposals for barges received and opened by Capt. C. McD. Townsend, Corps of Engineers, June 8, 1891.

No.	Name of bidder.	Per barge.	Remarks.
1	Wiegel Brothers	$2,475	Accepted.
2	David L. Barmore	3,210	

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Abstract of proposals for material received and opened by Capt. C. McD. Townsend, Corps of Engineers, June 10, 1891.

STONE.

No.	Name of bidder.	Ashbrook.			Greenville.			
		On bank at work.	On bank at Arkansas City.	On barges at work.	On barges at Greenville.		On bank at Greenville.	On bank at Arkansas City.
		Per yard.	*Per ton.*	*Per yard.*	*Per yard.*	*Per yard.*	*Per ton.*	*Per ton.*
8	W. L. Killebrew	....	$2.09	$2.19	$2.19	....	....	$2.09
11	J. H. McCarthy	....	2.24	....	2.89	....	....	....
12	Little Rock Granite Co.*	....	1.50	....	....	....	....	....
13	Joseph Evins	....	1.90	....	....	....	....	1.90
14	Fred Hartweg	$2.10	2.10	2.10	2.10	$2.10	....	2.10
15	W. E. Hunt†	....	....	....	....	....	$1.99½	....
16	Johnston Barrett	2.79	....	2.49	2.49	2.79	....	....

* Contract awarded for stone at Ashbrook Neck.
† Contract awarded for stone at Greenville.

BRUSH AND POLES.

No.	Name of bidder.	Ashbrook.		Greenville.		Louisiana Bend.	
		Brush.	Poles.	Brush.	Poles.	Brush.	Poles.
		Per cord.	*Per cord.*	*Per cord.*	*Per cord.*	*Per cord.*	*Per cord.*
1	Hunter & Frey *	$1.12	$1.75	$1.10	$1.75	....	....
3	W. L. Killebrew†	1.33	2.90	1.48	2.74	$1.14	$2.74
4	Elisha Evins ‡	....	....	....	....	1.17½	1.97½
13	Joseph Evins	1.12	1.80	1.12	1.90	1.37	2.25

* Contract awarded for brush and poles at Greenville and Ashbrook.
† Contract awarded for brush at Louisiana Bend.
‡ Contract awarded for poles at Louisiana Bend.

Proposals for material received and opened by Capt. C. McD. Townsend, Corps of Engineers, June 10, 1891.

Name of bidder.	Wire, per 100 pounds.	[illegible]-inch strand, per 100 pounds.	[illegible]-inch strand, per 100 pounds.	Cable, 400-foot lengths, per 100 feet.	Cable, 200-foot lengths, per 100 feet.	Spikes, 7 by ¼ inches, per 100 pounds.	Spikes, 9 by 5/16 inches, per 100 pounds.	Clevises, per 100 pounds.	Staples, per 100 pounds.	Manila rope, per 100 pounds.
Harry E. Coffin*	$2.79	$4.81	$4.81	$17.95	$18.68	$2.59	$2.59	$4.99	$2.99	$9.22
S. E. Forsaith Manufacturing Co	3.40	5.25	5.49	22.70	22.70	2.99	2.99	5.45	7.25	10.75
Lee Brothers & Co	......	5.20	5.20	20.40	20.40	......	2.59	......	......	9.05
Broderick & Bascom Co. †	2.83	4.82	5.16	20.81	21.65	......	......	......	......	9.00
Livermore F. and M. Co	2.84	4.96	5.33	27.29	21.72	2.70	2.70	5.25	6.50	9.75
M. M. Buck & Co. ‡	3.12	5.06	5.37	20.31	21.70	2.96	2.96	4.15	5.53	11.00
W. H. Langdale	......	......	......	......	......	......	......	......	......	9.24

* Contract awarded for wire, strand, cable, spikes, and staples.
† Contract awarded for manila rope.
‡ Contract awarded for clevises.

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Abstract of proposals for stone for Louisiana Bend, Louisiana, received and opened by Capt. C. McD. Townsend, Corps of Engineers, March 28, 1892.

No.	Name and residence of bidder.	Price bid per yard or ton.	Estimated cost of towage per yard or ton.	Total cost per yard or ton.	Total cost of 15,000 yards delivered.	Remarks.
1	Joseph Evins, Dardanelle, Ark.	$0.55	$0.64	$1.19	$17,850	On U. S. barges above Jacksonport, Ark., 528 miles.
2	Harvey S. Irwin, Louisville, Ky.	.65	.72	1.37	20,550	On U. S. barges at Apple Creek, Mo., 600 miles.
4	J. V. Hoag, jr., Pittsburg, Pa.	2.60	......	2.60	39,000	On contractor's barges at Louisiana Bend.
		2.30	......	2.30	34,500	On U. S. barges at Louisiana Bend.
5	W. E. Hunt, Greenville, Miss.	2.50	.18	2.68	40,200	On U. S. barges, Greenville, Miss., 42 miles.
		1.90	.18	2.08	31,200	On bank at Greenville, Miss.
6	Fred. Hanger, Little Rock, Ark.	1.24	......	1.24	18,600	On U. S. barges at Louisiana Bend.
		.98	.26	1.24	18,600	On U. S. barges at mouth White River.
7	Frederick Hartweg, Dayton, Ky.	.60	.74	1.34	20,100	On U. S. barges at Rosiclare, Ill., 620 miles.
		1.97	......	1.97	29,550	On contractor's barges at Louisiana Bend,
		2.24	......	2.24	33,600	On bank at Louisiana Bend.
8	Lewis F. Kavanaugh and Ayers A. Strange, Memphis, Tenn.	1.58	.41	1.99	29,850	On U. S. barges at West Memphis, Ark., 290 miles.
9	Edward Hely, West Plains, Mo.	1.58	.41	1.99	29,850	Do.
10	W. L. Killebrew, Vicksburg, Miss.	$1.74\frac{9}{10}$	.22	$1.96\frac{9}{10}$	29,535	On bank at Arkansas City, Ark., 82 miles.
		$1.74\frac{9}{10}$	.18	$1.92\frac{9}{10}$	28,935	On bank at Greenville, Miss., 42 miles.
		$1.74\frac{9}{10}$	.40	$2.14\frac{9}{10}$	32,235	On bank at West Memphis, Ark., 290 miles.
		$1.19\frac{9}{10}$	.46	$1.65\frac{9}{10}$	24,885	On U. S. barges at Searcy, Ark., 348 miles.
11	Elisha Evins, Memphis, Tenn.	5,000 at $0.49	.46	.95	4,750	All on U. S. barges at Buzzards Roost, Ark., 348 miles; United States to take to any point.
		10,000 at .60	.46	1.06	10,600	
		10,000 at .65	.46	1.11	11,100	

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Abstract of proposals for stone for Ashbrook Neck, Mississippi, received and opened by Capt. C. McD. Townsend, Corps of Engineers, March 28, 1892.

No.	Name and residence of bidder.	Price bid per yard or ton.	Estimated cost of towage per yard or ton.	Total cost per yard or ton delivered.	Total cost of 10,000 yards delivered.	Remarks.
1	Joseph Evins, Dardanelle, Ark.	$0.55	$0.51½	$1.06½	$10,650	On U. S. barges above Jacksonport, Ark., 435 miles.
2	Harvey S. Irwin, Louisville, Ky.	.65	.64	1.29	12,900	On U. S. barges at Apple Creek, Mo., 524 miles.
3	Johnston Barrett, Frankfort, Ky.	1.97	....	1.97	19,700	On contractor's barges at Ashbrook Neck.
4	J. V. Hoag, jr., Pittsburg, Pa.	2.12	....	2.12	21,200	On U. S. barges at Ashbrook Neck.
		2.42	....	2.42	24,200	On contractor's barges at Ashbrook Neck.
5	W. E. Hunt, Greenville, Miss.	2.15	.05	2.20	22,000	On bank at Huntington, Miss., 6 miles.
6	Fred Hanger, Little Rock, Ark.	1.19	....	1.19	11,900	On U. S. barges at Ashbrook Neck.
		1.63	.05	1.68	16,800	On bank at Arkansas City, 6 miles.
7	Fred Hartweg, Dayton, Ky.	.60	.66	1.26	12,600	On U. S. barges at Rosiclare, Ill., 544 miles.
		1.97	....	1.97	19,700	On contractor's barges at Ashbrook Neck.
		2.24	....	2.24	22,400	On bank at Ashbrook Neck.
8	Lewis F. Kavanaugh and Ayers A. Strange, Memphis, Tenn.	1.58	.33	1.91	19,100	On U. S. barges at West Memphis, 444 miles.
9	Edward Hely, West Plains, Mo.	1.58	.33	1.91	19,100	Do.
10	W. L. Killebrew, Vicksburg, Miss.	1.19$\frac{9}{10}$	.37	1.56$\frac{9}{10}$	15,690	On U. S. barges at Searcy, Ark., 262 miles.
		1.74$\frac{9}{10}$	.05	1.79$\frac{9}{10}$	17,990	On bank at Arkansas City, Ark., 6 miles.
11	Elisha Evins, Memphis, Tenn.	5,000 at $0.49	.37	.86	4,300	All on U. S. barges at Buzzards Roost, Ark.; United States to take to any point, 262 miles.
		10,000 at .60	.37	.97	9,700	
		10,000 at .65	.37	1.02	10,200	
12	G. A. Bienert, Bald Knob, Ark.	1.75	.26	2.01	20,100	On U. S. barges at Helena, Ark., 138 miles.

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Abstract of proposals for stone for Greenville, Miss., received and opened by Capt. C. McD. Townsend, Corps of Engineers, March 28, 1892.

No.	Name and residence of bidder.	Price bid per yard or ton.	Estimated cost of towage per yard or ton.	Total cost per yard or ton delivered.	Total cost of 15,000 yards delivered.	Remarks.
1	Joseph Evins, Dardanelle, Ark.	$0.55	$0.58	$1.13	$16,950	On U. S. barges above Jacksonport, Ark., 474 miles.
2	Harvey S. Irwin, Louisville, Ky.	.65	.67½	1.32½	19,875	On U. S. barges at Apple Creek, Mo., 558 miles.
4	J. V. Hoag, jr., Pittsburg, Pa.	2.12	....	2.12	31,800	On U. S. barges at Greenville, Miss.
		2.42	....	2.42	36,300	On contractor's barges at Greenville, Miss.
5	W. E. Hunt, Greenville, Miss.	1.87½	....	1.87½	28,125	On bank at Greenville.
6	Fred Hanger, Little Rock, Ark.	1.22	....	1.22	18,300	On U. S. barges at Greenville.
		1.63	.18	1.81	27,150	On bank at Arkansas City, Ark., 40 miles.
7	Fred Hartweg, Dayton, Ky.	.60	.69½	1.29½	19,425	On U. S. barges at Rosiclare, Ill., 478 miles.
		1.97	....	1.97	29,550	On contractors' barges at Greenville.
		2.24	....	2.24	33,600	On bank at Greenville.
8	Lewis F. Kavanaugh and Ayers A. Strange, Memphis, Tenn.	1.58	.36½	1.94½	29,175	On U. S. barges at West Memphis, 248 miles.
9	Edward Hely, West Plains, Mo.	1.58	.36½	1.94½	29,175	Do.
10	W. L. Killebrew, Vicksburg, Miss.	1.19 9/10	.40	1.59 9/10	23,985	On U. S. barges at Searcy, Ark., 294 miles.
		1.74 9/10	....	1.74 9/10	26,235	On bank at Greenville.
11	Elisha Evins, Memphis, Tenn.	5,000 at $0.49	.40	.89	4,450	On U. S. barges at Buzzards Roost, Ark., 294 miles, United States to take to any point.
		10,000 at .60	.40	1.00	10,000	
		10,000 at .65	.40	1.05	10,500	

Abstract of proposals for stone for Delta Point, Louisiana, received and opened by Capt. C. McD. Townsend, Corps of Engineers, March 28, 1892.

No.	Name and residence of bidder.	Price bid per yard or ton.	Estimated cost of towage per yard per ton.	Estimated cost of loading per yard per ton.	Total cost per yard or ton delivered.	Total cost of 1,500 yards delivered.	Remarks.
1	Joseph Evins, Dardanelle, Ark.	$0.55	.67½	....	$1.22½	$1,842.50	On U. S. barges above Jacksonport, Ark., 565 miles tow.
2	Harvey S. Irwin, Louisville, Ky.	.65	.89	....	1.54	2,310.00	On U. S. barges at Apple Creek, Mo., 679 miles tow.
4	J. V. Hoag, jr., Pittsburg, Pa.	2.70	....	....	2.70	4,050.00	On contractor's barges at work.
		2.40	....	....	2.40	3,600.00	On U. S. barges at work.
5	W. E. Hunt, jr., Greenville, Miss.	2.40	.25	....	2.65	3,975.00	On U. S. barges at Greenville.
		1.90	.25	.26	2.41	3,615.00	On bank at Greenville.
6	Fred Hanger, Little Rock, Ark.	1.29	....	....	1.29	1,935.00	On U. S. barges at Delta Point.
		1.59	....	....	1.59	2,385.00	On bank at Delta Point.
7	Fred Hartweg, Dayton, Ky.	.60	.89½	....	1.49½	2,242.50	On U. S. barges at Rosiclare, Ill., 699 miles.
		2.33	....	....	2.33	3,495.00	On contractor's barges at Delta Point.
		2.63	....	....	2.63	3,945.00	On bank at Delta Point.
8	Lewis F. Kavanaugh, and Ayers A. Strange, Memphis.	1.58	.48	....	2.06	3,090.00	On U. S. barges at Memphis, Tenn., 369 miles.
9	Edward Hely, West Plains, Mo.	1.58	.48	....	2.06	3,090.00	Do.
10	W. L. Killebrew	1.59	.12½	....	1.71½	2,572.50	On U. S. barges at Haines Bluff, Miss., 20 miles.
		2.09	....	....	2.09	3,135.00	On bank at Delta Point, La.
11	Elisha Evins, Memphis, Tenn.	5,000 at $0.49	.52	....	1.01	1,515.00	On U. S. barges at Buzzards Roost, Ark., 410 miles., U. S. to take to any point.
		10,000 .60	.52	....	1.12	1,670.00	
		10,000 .65	.52	....	1.17	1,755.00	

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Abstract of proposals for stone for Bolivar, Miss., received and opened by Capt. C. McD. Townsend, Corps of Engineers, March 28, 1892.

No.	Name and residence of bidder.	Price bid per yard or ton.	Estimated cost of towage per yard or ton.	Total cost per yard or ton, delivered.	Total cost of 1,500 yards, delivered.	Remarks.
1	Joseph Evins, Dardanelle, Ark.	$0.55	$0.49	$1.04	$1,560.00	On U. S. barges above Jacksonport, Ark., 383 miles.
2	Harvey S. Irwin, Louisville, Ky.	.65	.61	1.26	1,890.00	On U. S. barges at Apple Creek, Mo., 497 miles.
3	Johnston Barrett, Frankfort, Ky.	1.97	....	1.97	2,955.00	On contractor's barges at Bolivar.
4	J. V. Hoag, jr., Pittsburg, Pa.	2.49	....	2.49	3,735.00	Do.
		2.19	....	2.19	3,285.00	On U. S. barges at Bolivar.
5	W. E. Hunt, Greenville, Miss.	2.15	.13	2.28	3,420.00	On bank at Arkansas City, Ark.
6	Fred Hanger, Little Rock, Ark.	1.17	....	1.17	1,755.00	On U. S. barges at Bolivar.
		1.64	.13	1.77	2,655.00	On bank at Arkansas City, Ark.
		60	.63	1.23	1,845.00	On U. S. barges at Rosiclare, Ill., 517 miles.
7	Fred Hartweg, Dayton, Ky.	1.97	....	1.97	2,955.00	On contractor's barges at Bolivar.
		2.24	....	2.24	3,360.00	On bank at Bolivar.
8	Lewis F. Kavanaugh and Ayers A. Strange, Memphis, Tenn.	1.58	.31½	1.89½	2,842.50	On U. S. barges at West Memphis, Ark., 187 miles.
9	Edward Hely, West Plains, Mo.	1.58	.31½	1.89½	2,842.50	Do.
10	W. L. Killebrew, Vicksburg, Miss.	1.19 9/10	.35	1.54 9/10	2,323.50	On U. S. Barges at Searcy, or Newport, Ark., 228 miles.
11	Elisha Evins, Memphis, Tenn.	5,000 at $0.49	.35	.84	1,260.00	On U. S. barges at Buzzards Roost, Ark., 228 miles, United States to take to any point.
		10,000 at .60	.35	.95	1,425.00	
		10,000 at .65	.35	1.00	1,500.00	

Abstract of proposals for construction of levees, Tensas Basin, in Arkansas, received and opened by Capt. C. McD. Townsend, Corps of Engineers, September 28, 1891.

No.	Name of bidder.	Opossum Fork Levee.	Sunnyside Extension Levee.
1	Robert Johnson	$0.28½	$0.18½
2	Flynn & De Garis	.28	.21
3	A. A. Arnold & Co	.27 3/10	.16 7/10
4	T. S. Aderholdt	....	.14 7/10
6	Smith & Campbell	....	.24½
8	James A. Deaton	.38	.15 80/100
9	Timothy Sullivan	....	.17 48/100
10	Patrick F. Lamb	....	.18
12	J. E. Mulcahey and J. M. Sullivan	....	.15 44/100
13	McLaughlin & Hayse	....	.14½
14	Alex. Eltringham	....	.17 74/100
15	Andrews Brothers Construction Co.	....	.18
16	Scott & Garbish	.27 9/100	....
16a	T. W. Scott & Co	....	.18½
18	Joseph M. Whitehill	.25*	....
23	Campbell & Garigan	....	.18½
25	Charles H. Bodkin	.29 9/10	....
28	W. A. Shippey & Co	....	.21½

* Contract made.

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Abstract of informal proposals for levee work, received and opened by Capt. C. McD. Townsend, Corps of Engineers, March 17, 1892.

No.	Name and residence of bidder.	Boggy Bayou, second crossing.	Gains Landing.	Leland.
		Per cu. yd.	*Per cu. yd.*	*Per cu. yd.*
1	Timothy Sullivan, Memphis, Tenn	$0.16\frac{85}{100}$	$0.16\frac{75}{100}$	$0.16\frac{75}{100}$
2	McLaughlin Bros., Memphis, Tenn	.17½	.17½	
3	J. M. Whitehill, Arkansas City, Ark	.14		
4	C. F. DeGaris, Memphis, Tenn	.16¾	.17¾	.18 and .15
5	J. C. Hodge, Memphis, Tenn	.17	.16	.18
6	E. Hyner, Greenville, Miss	.15		
7	A. A. Arnold, Memphis, Tenn	.15⅞	.16⅝ .17⅝	 .21⅞
8	J. M. Sullivan, Vicksburg, Miss	.15		
9	O. B. Crittenden, Gaines Landing, Miss	.18	.16	
10	Benjamin Talley, Greenville, Miss *	.13¾*		
11	Thos. Chovrall, Luna Landing, Ark			.14½
12	Wm. Rode Koffer, Arkansas City, Ark	.16½		

*Contract awarded.

Abstract of proposals for construction of levees, Tensas Basin, in Louisiana, received and opened by Capt. C. McD. Townsend, Corps of Engineers, September 28, 1891.

No.	Name of bidder.	Illawara levee.
		Per cu. yd.
1	Robt. Johnson	$0.16¾
2	Flynn & De Garis	.21⅞
3	A. A. Arnold & Co	.22⅛
8	Jas. A. Deaton	$.17\frac{75}{100}$
12	J. E. Mulcahey and J. M. Sullivan*	$.16\frac{70}{100}$*
13	McLaughlin & Hayse	.17
15	Andrews Bros. Construction Co	$.17\frac{24}{100}$
17	John Scott & Son	$.16\frac{37}{100}$
19	Lohman & Evans	$.16\frac{95}{100}$
21	Jeffries & Dameron	.20¾
22	Ware & Donaven	$.16\frac{42}{100}$
27	John Bavonset	$.16\frac{64}{100}$

*Contract made.

Abstract of proposals for construction of levees, lower Mississippi levee district, received and opened by Capt. C. McD. Townsend, Corps of Engineers, September 28, 1891.

No.	Name of bidder.	Greenville Levee.	Stella Crevasse Levee.	Shipland Levee.
		Per cu. yd.	*Per cu. yd.*	*Per cu. yd.*
1	Robert Johnson	$0.16	$0.41	$0.14¾
2	Flynn & DeGaris		.24	.17¾
3	A. A. Arnold & Co	.15	.22	.14
4	T. S. Aderholt	.14½		$.13\frac{7}{10}$
5	Ernest Hyner		.38	$.15\frac{88}{100}$
6	Smith & Campbell		.26½	.17⅞
7	Jno. A. Cannon	.14⅞		
8	Jas. A. Deaton	$.16\frac{49}{100}$	$.28\frac{49}{100}$	$.13\frac{87}{100}$
9	Timothy Sullivan	$.16\frac{88}{100}$	.18½*	$.15\frac{88}{100}$
10	Patrick F. Lamb	.20	.18½	.15
11	W. S. Withers	.18		.17
12	J. E. Mulcahy and J. M. Sullivan			.13½
13	McLaughlin & Hayse	.16½	.27	.13
14	Alex. Eltringham			.14
15	Andrews Bros. Construction Co	$.14\frac{44}{100}$		$.14\frac{84}{100}$
16	Scott & Garbish	.16½	.38½	
16a	T. W. Scott & Co			.12⅞*
20	Shelton, Bagnell & Green	.15		
21	Jeffries & Dameron	.15½		.16½
22	Ware & Donaven	.13¼*		.14
23	Campbell & Garigan		.43½	
24	Pardesky & Lyman	$.14\frac{47}{100}$		$.12\frac{97}{100}$
26	L. C. Dulaney			.16
27	John Bavonset			$.15\frac{48}{100}$
28	W. A. Shippey & Co	.19½		$.14\frac{98}{100}$

* Contract made.

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Abstract of informal proposals for construction of Ashbrook Neck Levee in Mississippi, received and opened by Capt. C. McD. Townsend, Corps of Engineers, November 27, 1891.

No.	Name of bidder.	Price per cubic yard.
1	P. F. Lamb	\$0.16. \$20 per acre for slashing.
2	A. A. Arnold & Co*	.16$\frac{5}{8}$
3	Flynn & De Garis	.18$\frac{3}{4}$*
4	J. A. Ware	Station 1 to 81, \$0.21; 1 to 69, \$0.17$\frac{1}{2}$.
5	W. A. Shippey	\$0.19$\frac{81}{100}$.
6	Tim. Sullivan	.25
7	W. R. Harvey	.18
8	Withers & Montgomery	.19$\frac{1}{2}$
9	Shelton & Co†	.14$\frac{73}{100}$†

* Contract awarded. † Proposal withdrawn at request of contractor and his bondsman.

Abstract of informal proposals for construction of Catfish Point Levee, in Mississippi, received and opened by Capt. C. McD. Townsend, Corps of Engineers, December 1, 1891.

No.	Name of bidder.	Price per cubic yard.
1	John A. Ware*	\$0.14*
2	P. F. Lamb	.14
3	Timothy Sullivan	.17$\frac{1}{2}$
4	Flynn & De Garis	.16
5	M. McTighe & Co	.17$\frac{1}{2}$

* Contract awarded.

Financial statement.

LAKE PROVIDENCE REACH.

Balance June 30, 1891		\$389,565.79
Withdrawn	\$125,000.00	
Transferred to Greenville	48,000.00	
Transferred to Ashbrook Neck	48,000.00	
Transferred to plant	26,000.00	
Expended to May 31, 1892	108,007.27	
		355,007.27
Balance May 31, 1892		34,558.52
In hand		34,558.52
Less amount covered by existing contracts and liabilities		11,558.52
Available balance May 31		23,000.00
Expenditures apportioned:		
Labor on construction		29,898.77
Material for construction		42,768.43
Subsistence		9,622.54
Cost of plant, repairs, and outfit		9,391.06
Care of public property		1,246.49
Towage and steamer expenses		9,491.80
Administration and office expenses		4,011.06
Medicines and medical attendance		588.15
Miscellaneous		988.97
Total		108,007.27
Amount that can be profitably expended during fiscal year ending June 30, 1894		750,000.00

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Financial Statement.

VICKSBURG, MISSISSIPPI.

Balance June 30, 1891		$84,464.40
May 17, 1891, transferred to Atchafalaya and Red River, fourth district	$3,000.00	
Expended to May 31, 1892	36,548.09	
		39,548.09
Balance May 31, 1892		44,916.31
In treasury	47,500.00	
Due other allotments	2,583.69	
Less amount covered by existing contract and liabilities	14,916.31	
Reserved for repairs to Delta Point	15,000.00	
		29,916.31
Available balance May 31, 1892		15,000.00

Expenditures apportioned:	
Cost of plant, outfit, and repairs	2,640.04
Subsistence	225.98
Care of public property	76.00
Administration and office expenses and inspection	1,672.84
Dredging under contract	31,610.96
Mileage, traveling expenses, and miscellaneous	322.27
	36,548.09

Financial Statement.

GREENVILLE, MISSISSIPPI.

Balance June 30, 1891	194,786.26
October 23, 1891, by transfer from Lake Providence	25,000.00
December 5, by transfer from Lake Providence	23,000.00
Total	242,786.26
Expended to May 31, 1892	193,074.99
Balance May 31, 1892	49,711.27
In hand	4,711.27
In Treasury	45,000.00
	49,711.27
Less amount covered by existing contracts and liabilities	24,711.27
Available balance May 31, 1892	25,000.00

Expenditures apportioned:	
Labor on construction	57,982.67
Material for construction	99,763.65
Subsistence	14,039.77
Cost of plant, repairs, and outfit	4,062.49
Care of public property	1,762.50
Towage and steamer expenses	12,682.40
Administration and office expenses	1,192.64
Medicines and medical attendance	961.05
Miscellaneous	627.82
	193,074.99

Amount that can be profitably expended during the fiscal year ending June 30, 1894	200,000.00

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Financial Statement.

ASHBROOK NECK.

Balance June 30, 1891		$214,961.85
October 23, 1891, by transfer from Lake Providence		25,000.00
December 5, 1891, by transfer from Lake Providence		23,000.00
Deposited for overpayment of voucher		.30
		262,962.15
Expended to May 31, 1892	$145,765.21	
Transferred to Bolivar	6,000.00	
		151,765.31
Balance May 31, 1892		111,196.84
In hand		14,196.84
In treasury		97,000.00
		111,196.84
Less amount covered by existing contracts, and liabilities		31,196.84
Available balance May 31, 1892		80,000.00
Expenditures apportioned:		
Labor on construction		28,648.72
Material for construction		88,662.18
Subsistence		8,646.50
Cost of plant, repairs, and outfit		7,986.72
Care of public property		967.45
Towage and steamer expenses		12,782.46
Administration and office expenses		2,962.32
Medicines and medical attendance		702.20
Miscellaneous		406.76
		151,765.31

Financial Statement.

PLANT, THIRD DISTRICT.

Balance June 30, 1891	78,533.30
November 17, 1891, by tranfer from Levees White River Basin, 2d district.	331.17
December 5, by transfer from Lake Providence	26,000.00
	104,864.47
Expended to May 31, 1892	89,399.67
Balance May 31, 1892	15,464.80
In Treasury	16,000.00
Due other allotments	535.20
	15,464.80
Less liabilities	3,464.80
Available balance, May 31, 1892	12,000.00
Expenditures apportioned:	
Labor on repairs	31,352.71
Material for repairs	15,854.89
Care of plant, labor	3,780.00
Subsistence	9,954.24
Cost of plant, outfit, and supplies	28,153.68
Administration and office expenses	304.15
	89,399.67
Amount that can be profitably expended during the fiscal year ending July 30, 1894	150,000.00

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Financial Statement.

SURVEYS, GAUGES, AND OBSERVATIONS, THIRD DISTRICT.

Balance June 30, 1891	$5,397.09
Expended to May 31, 1892	4,871.71
Balance May 31	525.38
In Treasury	1,000.00
Due other allotments	474.62
Less liabilities	525.38
Available balance, May 31, 1892	000,000.00
Expenditures apportioned:	
Pay gauge observers	810.00
Discharge observations	891.33
Surveys	1,400.20
Steamer expenses	1,298.00
Outfit and material and stationery	385.48
Miscellaneous	86.70
	4,871.71
Amount that can be profitably expended during the fiscal year ending June 30, 1894	12,000.00

Financial Statement.

LEVEES LOWER MISSISSIPPI LEVEE DISTRICT.

Balance June 30, 1891	89,743.99
August 31, 1891, transferred from Lake Providence	9,825.00
Transferred from Lake Bolivar	1,136.15
May 16, 1892, transferred from Helena second district	5,000.00
May 26, 1892, transferred from Helena second district	2,000.00
	107,705.14
Expended to May 31, 1892	104,615.48
Balance May 31, 1892	3,089.66
In treasury	7,000.00
Due other allotments	3,910.34
Liabilities	3,089.66
No available balance.	
Expenditures apportioned:	
For levee construction and repairs	94,562.78
For engineering and office expenses	4,320.76
For high water protection	5,731.94
	104,615.48
Amount that can be profitably expended during fiscal year ending June 30, 1894—	
For construction	500,000.00
For high water protection	10,000.00

Financial Statement.

LEVEES, TENSAS BASIN, THIRD DISTRICT, IN ARKANSAS.

Balance June 30, 1891	168,217.24
Allotted	14,250.00
Transfer from Lake Bolivar	11,647.00
Deposit for overpayment of voucher	.05
Transfer from general service	5,000.00
Transfer from Helena	13,000.00
	212,114.29

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Expended to May 31, 1892	$146,228.92
Transferred to levees, Tensas Basin, in Louisiana	43,165.97
	189,394.89
Balance May 31, 1892	22,719.40
In Treasury	18,000.00
In hand	4,719.40
Less amount covered by existing contracts and liabilities	22,719.40

No available balance.

Expenditures apportioned:	
Levee construction and repairs	130,559.30
Engineering and office expenses	8,687.67
High-water protection	6,981.95
	146,228.92
Amount that can be profitably expended during fiscal year ending June 30, 1894—	
For construction	750,000.00
For high water	25,000.00

Financial Statement.

LEVEES TENSAS BASIN, THIRD DISTRICT, IN LOUISIANA.

Balance June 30, 1891	38,908.18
Transferred from Lake Providence	10,219.00
Transferred from levee, Tensas Basin, in Arkansas	43,165.97
Transferred from Lake Bolivar	1,181.00
	93,474.15
Expended to May 31, 1892	87,497.00
Balance May 31, 1892	5,977.15
In hand	5,977.15
Liabilities	5,977.15

No available balance.

Expenditures apportioned:	
Construction and repair of levees	82,789.47
Engineering and office expenses	4,015.71
High-water protection	691.82
	87,497.00
Amount that can be profitably expended during fiscal year ending June 30, 1894—	
Construction	500,000.00
High water	10,000.00

Financial Statement.

DRY DOCK, THIRD DISTRICT.

Allotted	20,000.00
Expended to May 31, 1892	19,988.57
Balance May 31	11.43
In Treasury	12,500.00
Due other allotments	12,488.57
Less liabilities	11.43

No available balance.

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Expenditures apportioned:

Construction of dry dock	$19,660.00
Services superintendent of construction	165.00
Mileage and travel expenses	163.57
	19,988.57

Financial Statement.

LAKE BOLIVAR FRONT.

Transferred from Ashbrook Neck	$6,000.00
Nothing expended.	
Amount covered by existing contracts	1,000.00
Available balance, May 31, 1892 (in Treasury)	5,000.00

Approximate value of plant belonging to the United States and used upon the third district, Mississippi River, May, 1892.

Class of Property.	Pieces.	Approximate value.	Class of property.	Pieces.	Approximate value.
Steamboats—			Barges—Continued.		
Etheridge	1	$9,720	Square (decked)	34	$16,867
Osceola	1	7,776	Machine shop (with outfit)	1	2,430
Vidalia	1	6,768	Carpenter shop	1	000
Meter	1	3,240	Pile-drivers and machinery	6	6,000
Steam tug Parker	1	4,860	Small scow	1	10
Mattress boats	5	6,075	Yawls	7	170
Quarter boat Headquarter	1	1,620	Skiffs	35	350
Quarter boat (with outfit)	9	7,290	Tools and appliances		900
Do	3	1,215	Office furniture, safe, etc		300
Hydraulic graders	2	19,440	Dump scows	2	8,100
Hydraulic grader (small)	1	2,000	Surveying instruments		2,000
Barges—			Dredge boat Menge	1	24,300
Model	10	12,960			
Square (new)	10	25,000	Total value		169,391

List of civilian engineers employed on work of river and harbor improvement, in charge of Capt. C. McD. Townsend, Corps of Engineers, from June 30, 1891, to May 31, 1892, inclusive, under the river and harbor acts approved August 11, 1888, September 19, 1890, and March 3, 1891.

Name and residence.	Time employed. Months.	Time employed. Days.	Compensation per month.	Where employed.	Work on which employed.
Arthur Hider, Greenville, Miss.	7	15	$250	Greenville, Miss	Care of and repairs to plant.
Do	1	15	250	do	Revetment at Greenville.
Do	2		250	Ashbrook Neck	Revetment at Ashbrook Neck.
E. C. Tollinger, Greenville, Miss.	5	16	175	Arkansas City, Ark	Construction and protecting levees in Arkansas.
Do	5	14	175	Ashton, La	Constructing revetment at Ashton, La.
H. St. L. Coppee, Vicksburg, Miss.	6	26	175	Vicksburg, Miss	Dredging in Vicksburg Harbor.
Do	4	4	175	Illawara, La	Construction of Louisiana levees.
Jno. J. Hoopes, Arkansas City, Ark.	9		150	Arkansas City, Ark	Construction and repair of Arkansas levees.
J. D. Van Meter, Longwood, Miss.	5		150	Longwood, Miss	Construction and repair of Mississippi levees.
W. S. Brown, Sunnyside, Ark.	5	14	150	Sunnyside, Ark	Construction and repair of Arkansas levees.
Do	1	16	150	Lake Providence, La	Construction and repair of Louisiana levees.
Henry Goodrich, Lake Providence, La.		22	175	Sunnyside, Ark	Construction and repair of Arkansas levees.
Do		27	175	Lake Providence, La	Construction and repair of Louisiana levees.

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APPENDIX 7.

REPORT OF LIEUTENANT JOHN MILLIS, CORPS OF ENGINEERS, ON OPERATIONS IN FOURTH DISTRICT.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., June 2, 1892.

SIR: I have the honor to submit the following report upon the works in charge of this office under the Mississippi River Commission for the period from July 1, 1891, up to May 31, 1892, in accordance with recent instructions from the Commission:

The office has charge under the Commission of the Fourth district, which extends from Warrenton, Miss., 7.4 miles below Vicksburg, to the Head of the Passes. The district comprises 484 miles of the river and includes the works of improvement at Natchez, Miss., and Vidalia, La., at the junction of the Mississippi, Red, and Atchafalaya rivers, near Turnbull Island, Louisiana, and at New Orleans Harbor. It also comprises the work of construction, repair, and maintenance of a portion of the levee system of the district; the maintenance of certain gauges, and certain surveys, observations, and other special work.

IMPROVEMENT OF THE MISSISSIPPI RIVER AT NATCHEZ, MISSISSIPPI, AND VIDALIA, LOUISIANA.

At its meeting of November 26, 1890, the Commission directed that a resurvey of those portions of the river which included the proposed works of improvement be made, and the sum of $1,500, was allotted for the purpose.

This survey was made as directed, and the report and map submitted with the last annual report from this office.

There have been no additional funds allotted and no further work was done during the past year.

The detrimental action of the river which the proposed works are intended to arrest still continues and probably at an increasing rate.

Money statement.

Natchez, Miss., survey.

July 1, 1892, balance unexpended	$114.69
June 30, 1892, expended during fiscal year	114.69

Improving harbor at Natchez, Miss., and Vidalia, La.

Amount that can be profitably expended during fiscal year ending June 30, 1894	$250,000

WORKS OF IMPROVEMENT AT THE JUNCTION OF THE MISSISSIPPI, RED, AND ATCHAFALAYA RIVERS, AT TURNBULL ISLAND, LOUISIANA.

The condition of the river channels in this vicinity is somewhat peculiar and confusing. Turnbull Island is approximately rectangular in shape and is about 6 miles long east and west, with an average breadth north and south of 2 miles. It is situated on the west side of the Mississippi River, about 200 miles above New Orleans, and its eastern extremity is now about a mile from the west bank of the river.

The island was formerly a peninsula connected by a narrow neck to what is now the east bank, and the main river passed around its western end. The Red River then emptied into the Mississippi opposite the northwest point of the peninsula, and the Atchafalaya was an outlet bayou or diffluent whose head was opposite the southwest point of the peninsula, about 2 miles below the mouth of the Red. Such was the condition of affairs at least as far back as 1578, the date of the earliest recorded observation by civilized man, and no material change took place until 1831, when the main river cut through the narrow neck, forming what is now called Turnbull Island.

The cut off is said to have been made or assisted by a Captain Shreve, and in some reports on this subject mention is made of difficulties of navigation which had previously been experienced owing to the shoal water found at the mouth of Red River during the low-water season, which the cut-off was designed to remedy.

It would seem entirely probable that prior to the cut-off a bar might have been

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formed at the mouth of Red River, which at low water would have impeded navigation, the same as now occurs at the mouth of the White, Arkansas, Yazoo, and other tributaries, and it is a matter of record that even since the cut-off and until a comparatively recent date the head of the Atchafalaya went nearly dry at low water, as does the outlet Bayou Lafourche at the present time.

Since the requirements of navigation prior to 1831 were quite different from those that exist at this date, comparisons of low-water difficulties, in the absence of accurate and reliable surveys, as they existed before and after the cut-off, are not very reliable.

A greater portion of the old river bed which was abandoned by the main river when the cut-off was made has become filled up with sediment, which has formed extensive bars that are dry except at high water and are thickly grown up with young trees. There is, however, a continuous channel around the island, much narrower than the original river, which still remains clear and navigable at high water, though the bottom of the portion north of the island is dry at low water and navigation through that portion south of the island is maintained during extreme low stages with difficulty. There are, besides these channels, various sloughs, lakes, and ponds in the old river bed that retain more or less water throughout the low-water season.

Another important change that has taken place since the cut-off is the general enlargement of the Atchafalaya in depth and width and its tendency to receive at certain stages the entire discharge of the Red River as well as a portion of that of the Mississippi. In fact the Red and Atchafalaya, with that portion of the old Mississippi River at the western end of the island between what was formerly the mouth of the Red and the head of the Atchafalaya as a connecting link, may now be regarded as forming really one river, which has a general direction parallel to that of the Mississippi, and which approaches the latter at Turnbull Island to within a distance of about 6 miles.

It must be noted, however, in considering the Red and Atchafalaya as one river, that a marked change in the characteristics of this river takes place at Turnbull Island. For a long distance above this point the slope is very gentle and the current sluggish and at certain periods nearly slackwater, or even a temporary reversed current may exist. The banks are low, heavily wooded, unleveed, always overflowed in high water, and are uninhabited.

Below Turnbull Island the section of the river, though constantly enlarging, is still much smaller than that immediately above, and the banks are high and cultivated. The west bank is leveed down to West Melville, 30 miles below Turnbull Island, while on the opposite bank the levee system now extends down about 17 miles below the island. The slope is much greater than that above, the current is swift, and the presence of numerous rafts or jams of trees and logs produces eddies and boils which render navigation unsafe without an experienced pilot. The banks are caving rapidly in many places.

About 40 miles below Turnbull Island the Atchafalaya begins to spread out into an intricate network of interconnecting bayous and lakes, mostly shoal, which finally reunite in the vicinity of Morgan City. The Bayou Teche, which is the principal distinct bayou to the westward of the Atchafalaya system, also comes in near Morgan City, forming a broad, deep bayou. This bayou continues, under the name Atchafalaya River, and after a course of about 35 miles, mainly through low sea marsh, it finally expands into Atchafalaya Bay, a shallow arm of the Gulf of Mexico.

The entire Red and Atchafalaya rivers system comprises in high water a total length of about 4,300 miles of navigable river, and in low water about 345 miles for a 3-foot draft and 132 miles for a 5-foot draft.

There is no available deep-water port on the Lower Atchafalaya, and the outlet for this entire system is now through the old Mississippi River channel south of Turnbull Island, which here forms a connecting link with the Mississippi, and thence by the Mississippi to the seaport of New Orleans. At high and medium stages of the river the channel north of Turnbull Island is also available, but it is less direct than the lower channel and is now seldom used.

The difficulties now experienced result from a tendency of the Old River to become filled up, owing partly to the absence of a definite current of sufficient strength to prevent the deposit of sediment and partly to the sliding down of the soft and recently formed banks. At low water the navigable connection between the Red and Atchafalaya system and the Mississippi is almost invariably seriously impaired and has been entirely interrupted in several instances.

Regarding the Red and Atchafalaya as one river, the direction and force of the current in the branches of Old River will evidently depend upon the relative height of the water in the Red and Atchafalaya system and in the Mississippi, and according as the one or the other of these two rivers happens to be the higher, or as they are both at the same level, the current through Old River is toward the east, toward the west, or is nil. In the first case there is a greater or less discharge from the Red and

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Atchafalaya system into the Mississippi; or, otherwise stated, Red River proper has then two outlets or branches, one through the Atchafalaya and one into the Mississippi, while the discharge of the Mississippi is confined entirely to its own channel.

In the second case the discharge of the Red and Atchafalaya is confined to its own channel, while a portion of the water of the Mississippi is diverted from that river and passes down the Atchafalaya.

In the third case the two river systems are independent so far as their discharge is concerned, which is then practically the same as would be the case if no connection existed.

During the flood period other influences have a material effect. The levee system on the west bank of the Mississippi is only completed down to Bougere, about 26 miles above Turnbull Island, and breaks in the levees above sometimes occur. The water from the Mississippi that escapes through breaks or crevasses above and that flowing over the bank between Bougere and Turnbull Island fills up the basin of the Lower Red and tends to maintain an equilibrium in the stage of the water in the two systems at Turnbull Island, and so prevent a current through the Old River. At such times there is a general set southward of the water covering the low swamps between the Lower Red and the Mississippi, forming a cross current which is partly interrupted by the high ground on the northwest portion of Turnbull Island and entirely stopped by the levee along the south bank of Lower Old River. The water from the Mississippi being much more heavily charged with sediment than that from the Red and its tributaries, it seems very probable that under these conditions the rate of filling, particularly in Upper Old River, is materially accelerated.

Since the bottom of Upper Old River has filled up to a level of about 13 feet above the zero of Barbres gauge, all action of a current from one river system to the other below that stage is confined to Lower Old River, and at higher stages the scouring action is no doubt weakened by being divided between two channels instead of being confined to one. The condition of absolutely no current through Lower Old River is comparatively rare, but the two river systems have at times remained at so nearly an equal stage while falling that not sufficient current between the two was formed to move the sediment that had been deposited during high water, and entire closure of the Old River channel during low stages has resulted.

Another serious difficulty has been experienced, due to the caving or sliding down of the soft banks of Lower Old River. The present channel being much narrower than when the main river occupied it, the banks are in many places of very recent formation. When the river falls to a very low stage the water is held in the adjacent ponds and sloughs at a higher level than in the channel, and the underlying strata of the banks are kept saturated. When no longer supported by a high stage of water in the channel, large masses of the soft banks slide down, and their weight causes lumps and ridges of the stiff clay comprising the bottom of the channel to rise up, frequently stopping navigation entirely until these lumps and ridges can be cut out.

The general object of the works of improvement now in progress is to rectify the defects above outlined, and the present project proposes to effect this by causing a separation of the Red from the Atchafalaya at Turnbull Island for all stages of these rivers below medium low water, making the Red a proper tributary to the Mississippi when it is at or below this stage, while the Atchafalaya becomes at the same time an outlet or "diffluent" of the Mississippi. The plan also contemplates preventing any further enlargement of the Atchafalaya, and the whole work is designed to have no material effect on the high-water regimen of the various rivers involved, and to produce no greater danger of injury to property from overflow than now exists.

This general project contemplates the following work: A series of low relief dams or sills, not to exceed six in number, to be built in the Atchafalaya proper at intervals of about a quarter of a mile. These dams to be located below the mouth of Bayou Des Glaise, near Simmesport, about 5 miles below Turnbull Island. These dams are designed to prevent further enlargement of the Atchafalaya and to limit its discharge capacity. They are to be built up of successive layers of mattresses made of willow brush and timber, ballasted with stone, and with intervening layers of mixed gravel and clay; the foot mattresses to have a width up and down stream of about 300 feet, and the maximum depth over the crest of the dam to be about 7 feet at extreme low water. The high-water discharge over these dams is intended to be equal to the flood discharge of Red River proper, or about 200,000 cubic feet per second.

A low relief dam is also to be built across the river from the west side of Turnbull Island to the mainland. This dam to be constructed of successive layers of willows and timber mattresses, with stone ballast, and its top and side slopes to be heavily paved with rock. The foot mattress has a maximum width up and down stream of 280 feet. The total length of the dam proper is 935 feet and of the shore-protecting mattresses about 2,039.

This dam is to effect the separation of the Red from the Atchafalaya at all stages of the water below the level of its crest and deflect Red River through Upper Old

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River. To complete the separation of the Red from the Atchafalaya a canal is to be cut from Upper Old River across Carrs Point to the Mississippi, and a dam or obstruction is to be built to close Upper Old River below the canal at some point opposite the eastern end of Turnbull Island.

To secure a navigable channel through Upper Old River it is to be deepened by dredging or otherwise, as may be found most expedient.

During the progress of the above work an attempt is to be made to temporarily maintain navigation through Lower Old River by dredging, washing the bottom with steam tugs, or by other expedients.

Up to the time of the last Annual Report the following work had been accomplished:

Two of the sill dams in the Atchafalaya, Nos. 1 and 3, had been completed.

The sill or foot mattress and shore protection of the Red River Dam were finished. The two lower courses of crib mats were in place and the third course had been constructed and a portion of it sunk in place.

Considerable dredging had been done both in Lower and Upper Old River, though the latter had not proved effective, owing to the nearly fluid state of the material in which the work was done.

The site of the proposed Carrs Point Canal had been partially cleared of trees, and dredging at the western end in an experimental way had been commenced. The telephone line to connect the works with West Melville, the nearest telegraph station, was partially completed and repairs to the barges and other portions of the plant were in progress.

The Commission having directed that the dam be raised temporarily to a height of 5 feet above low water, or the zero of Barbres gauge, in order to assist in increasing the current and consequently the scour in upper Old River during the falling stage of the water, work on the dam was resumed and continued until four courses were in place and a height of about 3 feet above the zero of the gauge obtained. The fourth course was not entirely completed.

The river continued to fall rapidly, finally reaching the unusually low stage of 1 foot below zero on November 17, and it became necessary to suspend work and carry out the instructions of the Commission given in anticipation of a season of extreme low water, and to remove a portion of the dam to permit boats to pass while the low water continued.

A part of the upper course of mats was therefore cut out by means of a dredge, leaving over the dam a clear channel, which for a width of 450 feet has a depth of about 5 feet below the zero of the gauge. In making this cut the rock taken out was distributed over the apron below the dam.

Meanwhile dredging was continued in upper Old River, but with no greater success than had attended previous work of the kind in that locality. In lower Old River the usual difficulties were experienced in maintaining the channel during low water, but to a much less degree than ever before at a corresponding stage of the water. Dredging began as soon as the water had fallen sufficiently to permit the dredge to work and was continued until the water became so low that the work had to be suspended.

The Government dredges *Menge* and *Pah Ute* and a Hayward bucket dredge, hired for the purpose, were used for this work, and operations were confined to the sand bar at the Mississippi end of Old River, to the "Second Crossing," and to the clay lumps and ridges in the vicinity of Ash Cabin and Dead Tree.

There was also a shoal place near Kellers, in the western portion of the lower Old River, caused by a deposit of sand, and several of the old temporary contracting dikes were repaired and new ones built, with a view to removing the sand by the scour of the increased current produced.

By October 6 the gauge at Barbres had fallen to 2 feet above zero and lower Old River had become impassable for the regular steamboats, though small light-draft boats continue to go through and transfer freight between Barbres and Torra's Landing until October 30, when the water had reached two-tenths below zero.

Navigation was suspended entirely from this date until November 27, when both the Red and the Mississippi rose rapidly and navigation was restored.

During the period when navigation was suspended through Old River there were of course difficulties in many other places and through boats could not have safely loaded deeper than 5 feet for any portion of the Red and Atchafalaya system which remained navigable. Even at the extreme lowest stage, 1 foot below zero on Barbres gauge, lower Old River at no point went entirely dry, as has always been the case heretofore; there being at the shoalest places a depth of not less than 1 foot. During the low water the small snag-boat *Florence*, which was loaned for the purpose through the courtesy of Capt. J. H. Willard, Corps of Engineers, U. S. A., did excellent work in lower Old River, clearing out snags and logs and the series of piling and old temporary dikes that had previously been constructed in attempts to maintain a low-water channel.

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From soundings taken during the lowest stage it was ascertained that to secure a channel throughout Old River from the Mississippi to the deep water near Barbre Landing, with a depth of 5 feet below zero and a bottom width of 75 feet, would have required the removal of only 75,000 cubic yards and had a dredge capable of working during low water in sand, stiff clay, and soft mud been available, this could easily have been effected, even with a plant of moderate capacity.

It is at least encouraging to note the apparent improvement in the channel of lower Old River. This channel was very much better last fall than it has ever been before at corresponding stages. In only one instance during the period of four years covered by the records of Barbre gauge in this office has the water been lower than it was in 1891. In 1887 the gauge went down to 1.5 feet below zero, and lower Old River went entirely dry. It has frequently been closed completely when the lowest stage was considerably above the zero of the gauge. The favorable state of affairs last fall may have been partially due to accidental causes, which resulted in maintaining such relative height between the Mississippi and the Red and Atchafalaya rivers during the falling stages as to produce a defined current through lower Old River for a long period and so prevent the deposit of sediment, but it is also believed to be attributable to a material extent to influences which are now permanent or favorably progressive. These influences are the improved condition of the Tensas Basin levee system, which has lessened the escape of the crevasse waters from the Mississippi into the Red and Atchafalaya system above Bougere during floods; the growth of trees and the increased deposits on the bars in lower Old River, tending to narrow the channel, which has a tendency to diminish the caving and the trouble resulting from the forcing up of clay lumps and ridges in the bottom of the channel; and possibly the natural filling up of upper Old River, which would have the effect of increasing the flow through the lower Old River when the conditions are favorable to such flow.

The continuation of the levee system south of Bougere, its present terminus, is a matter which should receive early consideration in connection with the improvement of navigation through Old River.

In high water the Mississippi now flows over the western bank and into the basin of the lower Red for the entire distance of 7 miles between Bougere and Union Point, carrying in a large amount of sediment and tending to maintain a condition of equilibrium between the stages of the Lower Red and of the Mississippi and thus to neutralize the current through Old River and hasten the progress of filling up. There are also several smaller gaps between Union Point and the mouth of Red River through which there is a large escape in extreme high water.

The Atchafalaya sill dams are still in good condition and no repairs were necessary during the year. The levee between the dams on the right bank had shown weakness during high water of 1891, requiring some work to stop holes and repair damage caused by sloughing. After the water went down the repairs were completed and a public road crossing constructed over the levee.

When the work was first started a site was leased and depot and store houses established opposite Simmesport. This was convenient to the Atchafalaya sill dams, but too far from the principal part of the work during the construction of the Red River dam and dredging operations in Old Rivers. A new site near Barbres Landing was therefore leased and the storehouses and property moved to it during December and January.

The telephone line was completed during September and has proved of very great value, particularly in the high-water season.

Extensive repairs to six of the large barges and to the steamer *Ruby*, besides minor repairs to other portions of the plant, were made during the year. Nearly all of the plant was employed on the work at Plaquemine and on levee duty when not needed at Turnbull Island. The dredge *Menge* was returned to the Third District in February, being required at Vicksburg and no longer available in Old River until the low-water season. The dredge *Pah Ute* and the tug *Comstock* were taken to New Orleans for repairs, which are now in progress, and all other parts of the floating plant were removed to New Orleans, where it can be cared for with greater economy.

In June 2,532 tons of rock were borrowed from that stored on Turnbull Island for use on the New Orleans Harbor work, and a like amount was returned to Turnbull Island during April, 1892, the expense of quarrying and delivering having been paid out of the allotment for New Orleans Harbor.

Observations were taken to determine both the extreme low-water and the extreme high-water discharges of the Mississippi at Red River Landing, and of the Atchafalaya at Simmesport. The low-water discharge at and immediately below the Red River dam was also measured.

During the extreme low water a careful survey was made to determine the condition of the Red River dam, and of the river bottom above and below. The field work was under the immediate charge of Assistant Engineer W. G. Price until

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September 20, when he was placed in charge of the work at Plaquemine and was relieved by Assistant Engineer G. Ed. Mott, who remained in charge until field work was closed for the season on February 12.

The gauge at Simmesport, which was established in connection with the work on the Atchafalaya sill dams, was discontinued on May 15.

Under direction of the Commission the officer in charge has visited and examined during the year most of the largest dredging plants in the United States and corresponded with a number of persons owning, operating, or manufacturing large dredging apparatus in this country and abroad. It having been decided to procure a dredging plant of the largest capacity practicable and of the most approved pattern for the work of opening Old River, specifications were prepared and advertisements for proposals issued on June 1, 1892, bids to be opened August 1.

RED AND ATCHAFALAYA RIVERS.

Money statement.

July 1, 1891, balance unexpended		$147, 109.28
May 8, 1892, transferred from Vicksburg Harbor		3, 000.00
May 4, 1892, transferred to New Orleans Harbor		8, 000.00
		142, 109.28
May 31, 1892, expended during fiscal year to date	$52, 241.70	
May 12, 1892, funds not called for by persons who have signed pay rolls	4.15	
		52, 237.55
May 31, 1892, balance available		89, 871.73
In Treasury United States		90, 000.00
Due other works		128.27
Available		89, 871.73
Amount that can be profitably expended during fiscal year ending June 30, 1894		350, 000.00

Assistant Engineer Mott's report covering the field operations for the year is as follows:

MERRICK, LA., *March 1, 1892.*

SIR: I have the honor to submit the following report on the work of improvement at the junction of the Mississippi, Red, and Atchafalaya rivers from June 1, 1891, to February 29, 1892. The conditions existing on the former date were as follows:

Upon the sill for the Red River Dam two full courses of crib mats and a portion of a third course had been sunk and well ballasted with rock, 54,000 square feet of mats, sufficient to complete the third course, were on hand awaiting a stage of water when it would be safe to sink them, the lowest point of the crest of the dam was 7½ feet below Barbre's zero, and there was a mean depth of 5 feet below zero for a width of 96 feet. Constant dredging in lower Old River had greatly improved the channel, while the considerable amount of dredging done in upper Old River had proved of little or no benefit; the route for the canal from upper Old River through Carrs Point to the Mississippi River had been surveyed, partially cleared, and some slight dredging done at the Old River end. The plant was in laying up quarters at the head of Turnbull Island and was in good condition with the exception of the barges which were undergoing repairs. A telephone line between West Melville, on the Texas and Pacific Railroad, and the head of the Atchafalaya River was in course of construction.

Red River Dam.—The eight mats (51,500 square feet) which remained on hand from last season were sunk as the third course on the dam in the latter part of June; the shore end began at a point 20 feet on Barbres gauge on the Turnbull Island side and stretched out on the dam 496 feet, being ballasted with 927 tons of rock; this course overlaid the other two courses and the small part of the third course which had been sunk the previous fall, and raised a portion of the crest of the dam to 3 feet on Barbres gauge; there was, however, a low place near the center about 120 feet wide, the lowest point of which was 3 feet below Barbres zero; the eastern end of the mats was placed well up on the bank to sustain it and prevent sloughing. The remaining mat (2,480 square feet) was sunk above the upper edge of the dam on the left bank as a shore protection to prevent caving. There

were cut and delivered in June and July 907 cords of willows, from which were constructed eight crib mats 68 by 80 by 3 feet; these were sunk in August on the western end of the dam, the shore end beginning at a point 20 feet on Barbre gauge and reaching out 544 feet on the dam; they were ballasted with 732 tons of rock; there was a gap of 90 feet between the river ends of this course and the third course, which had been sunk from the left bank; these courses were composed of mats 68 feet wide, wired together, and were sunk as one continuous mat across the current; this work was completed on August 10. An order was received on September 1 to remove a section of the upper course of mats in the center of the river for a distance of 300 feet in order to give a low-water channel of that width and 5 feet below Barbre zero; an attempt was made to blow out the section with dynamite, a large quantity being used, but charges of 100 pounds produced no effect other than to settle the work more compactly; a heavy anchor was then dragged over the section from the upper to the lower side of the dam, which had the desired effect, but the method was slow; a dredge fitted with a Hayward bucket was finally procured and the cut easily made. A section 260 feet wide and 4 feet deep, containing 83,200 cubic feet of material, was removed (the upper course only being cut away) and gave a channel 5 feet below Barbres zero; the willows floated away and the rock ballast was spread on the apron below; through this opening boats had no difficulty in passing until the water had fallen to 2¼ feet on Barbre gauge; at lower stages the dredge *Menge*, which had been previously located in mid stream above the dam, pulled several boats over without difficulty; at the lowest stage of the river, 1 foot below Barbre zero, Old River was entirely closed and boats could not reach the dam, but could have passed over it with the assistance of the dredge even at that low stage. In December the remaining portion of the west end of the third course of mats, a small section containing 19,200 cubic feet, was removed by dredging and there is now an opening over the center of the dam 450 feet wide, almost all of which has a depth of 5 feet below Barbre zero. About one-fourth of the third course of mats remains intact on the eastern end of the dam.

Upper Old River.—The dredge *Pah-Ute* began work in upper Old River on June 5, the dredged material being deposited at one side of the cut, and on the 21st, the depth of water being too great, the dredge was removed and laid up at the head of Turnbull Island, 18,921 cubic yards having been excavated. On June 9 the dredge *Menge* was put to work, and by the 18th of July had removed and deposited on one side of the cut 50,553 cubic yards of soft mud; the water then being too high, it was taken to the head of Turnbull Island and laid up. Both these dredges were in first-class condition, and during the time of their service did very cheap work.

The semiliquid character of the deposit in the bottom of upper Old River, between the junction of the three chutes and the foot of Turnbull Island, is shown by the fact that when the bed of the river was dry no traces of the large amount of dredging which had been done could be discerned.

Lower Old River.—On August 31 the dredge *Menge* began operations cleaning out the channel in lower Old River, between Ash Cabin and Dead Tree, depositing the material excavated on one side of the cut, and continued work until September 22, when the water became so shoal that the dredge was with difficulty removed and placed above the Red River Dam; 44,638 cubic yards of clay were removed during that period, and the work done was of great benefit during low water; the dredge *Pah-Ute* was at once substituted for the *Menge*, and succeeded until October 17 in keeping open the channel for light-draft boats even when the water was below the zero of Barbre gauge; 24,500 cubic yards of material were removed and a long line of channel kept open. The river near the Mississippi end had by this time become nearly closed with soft mud and sand, preventing the water from getting in Old River. The dredge was, therefore, moved to the second crossing on the 18th, and in three days' time a cut 2,000 feet long had been made towards the Mississippi, 2,600 cubic yards of semiliquid mud and sand was removed which, owing to its character, slid back almost as fast as it was cut out, and as the water still continued to fall the dredge was removed and laid up in the deep water at the foot of Turnbull Island; the dredge had been pushed to its utmost capacity, and had been at work for 30 days without the slightest cessation for repairs; the hull forward was leaking badly, and repairs were greatly needed. During this same period a cut was made through the sand bar at the mouth by a dredge fitted with a Hayward bucket, making a channel 6 feet deep and 40 feet wide; this dredge then continued on to the second crossing, and began digging to connect with the *Pah-Ute*, the conditions being the same as those affecting the *Pah-Ute*. The attempt was abandoned after 3 days' work, there being danger that the dredge would be caught and remain in Old River for a long period. The material removed by this latter dredge was 9,500 cubic yards, and it compared very unfavorably with both the *Menge* and *Pah-Ute* in economy and celerity and capacity for handling this kind of material. Barbre gauge at this time read three-tenths below zero

During the latter part of September and first part of October steamboats ex-

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perienced much difficulty from an accumulation of sand near the Atchafalaya end of lower Old River, and as there was a fair current from the Mississippi an attempt was made to scour this sand by refilling and enlarging six of the old pile dikes on the Turnbull Island side and building three new ones. The effect was at first good, the contraction of the channel having a marked effect on the sand reefs; but their efficiency was soon marred by a slight rise from the Red River, which checked the current. These dikes and many of the old piling in Lower Old River have since been removed by dredging.

The steamer *Florence*, which had been borrowed from Capt. J. H. Willard, Corps of Engineers, U. S. Army, was employed during October in removing snags near the Mississippi end of Old River and old pile dikes between Chandler Crossing and Ash Cabin, which has greatly improved navigation. The *Florence* also did considerable washing in the second crossing. Navigation in Old River for large steamboats was suspended on October 6, Barbres gauge then reading 2 feet above zero, but boats of light draft continued to pass through until the 30th, when Barbre gauge read two-tenths below zero, and all navigation was suspended. The river was at no time entirely dry, there being never less than 1 foot of water in the shoalest places, although on November 8 the gauge readings were as follows: Red River Landing, 1.4 above zero, and Barbre, 1.0 below zero. On November 27 navigation was resumed, heavy rains causing a rapid rise of the river with a strong current in from the Mississippi. Navigation was suspended and resumed at a much lower stage of water this season than in 1887, the last preceding low-water year.

During low water experiments were made in pumping the semiliquid deposit in Upper Old River. A centrifugal pump with 6-inch suction was used, and at a moderate rate of speed 70 per cent of mud was raised and discharged through the pump; experiments in sand were not as satisfactory, on account of the rigid suction.

On December 19 the dredge *Menge* was again put to work near Ash Cabin, but on the third day one of the cranes gave way, and as extensive repairs would be necessary before the dredge could be again used, it was towed to the depot and laid up. The material excavated at this time was 5,480 cubic yards.

Owing to the extreme low water of this season it was impossible to prevent cessation of navigation through Old River, the attempt to keep it open being attended with many difficulties. It was of the utmost importance to remove the mud lumps in the vicinity of Ash Cabin, where the channel was very narrow and crooked, and it was often necessary to move the dredge over 1,000 feet by hand to a wider place in order that boats might pass by. This necessitated pulling back into place again, and much time was lost, and as the steamer *Ruby* could not get into Old River it was necessary to handle the dredges entirely with their own power, and to supply them with fuel and material was a very difficult matter.

Sill dams on the Atchafalaya.—No work has been done on these dams since the slight repairs of last season, but an examination made during low water showed them to be in good condition and well silted up. Considerable sloughing had occurred to the levee on the right bank between Dams 1 and 3 during the last high water, it was therefore repaired and enlarged and a roadway built over it at the landing in July.

Miscellaneous.—The repairs to the six large barges were completed in September, and as fast as repaired they were transferred to Plaquemine, La. The plant received such minor repairs as were necessary to keep it in good condition, and false bottoms were put in the bins of the four scows, making them serviceable as coal or rock barges. The entire plant was transferred to the depot at Simmesport on August 12, and the location at the head of Turnbull Island abandoned.

On July 15 the launch *Alaska* was transferred to levees below Red River. On September 20 Assistant Engineer W. G. Price, who had been in local charge of this work up to that time, was transferred to Plaquemine, with the plant belonging to this work, the steamer *Ruby*, quarterboat *Gamma*, four scows and three old barges being left at the depot; I then assumed local charge at this station as directed. On September 24 the quarterboat *Gamma* was transferred to levees above Red River; on November 28 the dredge *Pah-Ute* was sent to New Orleans for repairs; on January 24 the steamer *Ruby* was transferred to levees above Red River. On February 13 the dredge *Menge* was returned to Capt. Townsend, who had loaned it to this work from the third district. The four scows and three old barges were sent to New Orleans, which completed the transfer of the entire floating plant belonging to this work.

During June, 1,688 additional tons of rock were delivered from the quarry for Plaquemine, and from the stone at the head of Turnbull Island 2,532 tons have since been transferred to New Orleans Harbor.

The telephone line between West Mellville and the head of the Atchafalya River was completed on July 14, and a cable was laid across the Atchafalaya at Simmesport in September, which now gives a continuous line of communication. The line was repaired and at several points moved inside of the newly constructed levees in December, and it is now in good working order.

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During December and January the location of the depot was changed from Simmsport to Barbre Point, at the head of the Atchafalaya; the buildings and property were moved, new buildings erected, and the property stored at the new location, the two old barges and four scows being utilized in making the transfer. This work having been completed on February 12, the depot was left in charge of two watchmen.

Surveys, gauges, and observations.—Permanent discharge sections have been established at Simmsport and Red River Landing, La. The one at Simmsport was moved upstream and located between the two dams. The one at Red River Landing was altered to a line at right angles with the current.

During extreme low water five discharge measurements were taken at Red River Landing, three at Simmsport, two just below the Red River Dam, and two on the Red River Dam, resulting as follows:

In the Mississippi River, at Red River Landing, La.

[B. J. Oliveira, observer.]

Direction and force of wind.	Date of observation.	Total area.	Mean velocity.	Discharge per second.	Red River Landing gauge.
		Sq. feet.	*Feet.*	*Cubic feet.*	*Feet.*
Light, downstream	Oct. 15	54,021	2.722	147,059	2.10
Light, upstream	Oct. 16	54,452	2.558	139,304	2.00
Brisk, upstream	Oct. 17	52,431	2.541	133,204	1.92
Do	Nov. 21	53,763	2.438	131,097	1.85
Do	Nov. 22	55,101	2.587	142,522	3.05

In the Atchafalaya River, at Simmesport, La.

[R. Y. Briggs, observer.]

Direction and force of wind.	Date of observation.	Total area.	Mean. velocity.	Discharge per second.	Simmesport gauge.
		Sq. feet.	*Feet.*	*Cubic feet.*	*Feet.*
Strong, downstream	Oct. 16	20,288	0.729	14,791	− 0.15
Light, upstream	Oct. 22	20,626	.740	15,200	− 0.55
Strong, upstream	Nov. 20				

In the Red River, below the Red River Dam.

[G. Ed. Mott, observer.]

Direction and force of wind.	Date of observation.	Total area.	Mean velocity.	Discharge per second.	Barbre gauge.
		Sq. feet.	*Feet.*	*Cubic feet.*	*Feet.*
Light, upstream	Oct. 22	10,930	1.094	11,968	− 0.2
Calm	Nov. 6	9,480	.783	7,373	− 0.9

In the Red River, on the Red River Dam.

[G. Ed. Mott, observer.]

Direction and force of wind.	Date of observation.	Total area.	Mean velocity.	Discharge per second.	Barbre gauge.	Sugar-house gauge.
		Sq. feet.	*Feet.*	*Cubic feet.*	*Feet.*	*Feet.*
Calm	Oct. 27	2,742	3.98	10,915	0.5	2.1
Do	Nov. 6	1,646	4.58	7,544	− 0.9	1.07

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In October a survey was made of the Red River Dam. Twenty-two sections at right angles to the dam extending from a line 500 feet above the dam to a line 500 feet below the dam were sounded and leveled, and cross sections at the extreme ends of these lines were sounded, and 3 lines of levels were run longitudinally over the dam. The water being at its lowest stage, the results were good.

The twelve gauges at Red River Landing and Simmesport, La., in use during the last high water for slope observations have been connected with lines of precise levels. The following are the minimum gauge readings during the past low water: November 13, Red River Landing, 0.9; November 7 and 8, Barbre, — 1.0; November 7, Sugar House, 0.1; November 8, Simmesport, — 1.6

Statement of cost of the different parts of the work.

RED RIVER DAM.

Sinking 218,624 cubic feet of mats on hand from last season	$895.80
Constructing and sinking 130,560 cubic feet of mats, including, 907 cords of willows cut and delivered	2,106.99
Care in keeping mats afloat	189.00
Value of mats on hand from last season	5,872.73
Value of 1,703.6 tons of rock used in sinking, at $3.11	5,298.19
395,181 cubic feet of material in place this season, at 3.68 cents	14,362.71
Cost of removing 102,400 cubic feet from dam	1,195.68
Value of rock on hand	16,992.98
Previous cost of dam	79,000.43
Cost of dam to date	111,551.80
Total 2,128,409 cubic feet of material placed in dam at 3.59 cents	76.464.29

UPPER OLD RIVER.

Dredge *Pah-Ute* excavated 18,921 cubic yards, at 2.7 cents	511.48
Dredge *Menge* excavated 117,398 cubic yards, at 1.15 cents	1,347.31
Cost of repairs to dredges, services of steamboats, etc	294.03
Total 136,319 cubic yards, etc., at 1.57 cents	2,152.82

LOWER OLD RIVER.

Dredge *Pah-Ute* excavated 23,002 cubic yards, at 3.5 cents	813.87
Dredge *Menge* excavated 54,291 cubic yards, at 3 cents	1,628.60
Dredge with *Hayward*, 13,179 cubic yards, at 13.66 cents	1,800.60
Cost of repairs to dredges, services of steamboats, etc	953.97
Total, 90,472 cubic yards excavated, at 5.74 cents	5,197.04
Cost of construction and repair of pile-drivers	866.39
Total cost	6,063.43

SILL DAMS IN THE ATCHAFALAYA.

Cost of repairing and enlarging levee at Simmesport	911.86

TELEPHONE LINE.

Cost of construction this season	2,180.29
Previous cost	1,830.30
Total cost	4,010.59

SURVEYS, GAUGES, AND OBSERVATIONS.

Cost this season	525.75

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CONSTRUCTION.

Cost of supervision, including subsistence and services of boats	$4,283.54
Cost of care of plant, including subsistence and services of boats	9,915.44
Cost of repairs to plant, including subsistence and services of boats	14,336.90
Cost of steamers when assigned to no particular part of work	1,282.34
Cost of Red River Dam this season	15,558.39
Cost of Upper Old River this season	2,152.82
Cost of Lower Old River this season	6,063.43
Cost of repairing levees at Simmesport	911.86
Cost of telephone line this season	2,180.29
Total	56,685.01

SUBSISTENCE.

Cost of cooking and serving rations		1,998.47
(Cost per ration, 13 cents.)		
Regular rations furnished	$13,782	
Extra rations furnished	20	
Cooks, etc., rations furnished	1,598	
Total rations furnished	15,400	
Value of subsistence stores consumed		6,224.51
(Cost per ration, 40 cents.)		
Value of 15,400 rations furnished, cooked, and served		8,222.98
(Cost per ration, 53½ cents.)		
Cost of tug *Comstock* while in commission, including fuel, material, etc., 107 days, at $20.89 per day		2,235.10
Cost of steamer *Ruby* while in commission, including fuel, material, etc., 207 days, at $15.90 per day		3,291.93
Cost of launch *Alaska* while in commission, including fuel, material, etc., 6 days, at $12.90 per day		77.39

Cost of dredge *Pah-Ute* while in commission:	
Excavated in Lower Old River, 23,002 cubic yards, at 3.5 cents	813.87
Excavated in Upper Old River, 18,921 cubic yards, at 2.7 cents	511.48
Excavated a total of 41,923 cubic yards, at 3.16 cents	1,325.35
Cost of dredge *Menge* while in commission:	
Excavated in Lower Old River, 54,291 cubic yards, at 3 cents	1,628.60
Excavated in Upper Old River, 117,398 cubic yards, at 1.15 cents	1,347.31
Excavated a total of 171,689 cubic yards, at 1.73 cents	2,975.91
Cost of repairs to dredge	977.52
Total	3,953.43
(Cost per cubic yard, 2.3 cents.)	
Cost of work done for New Orleans Harbor	45.27
Value of rock transferred to New Orleans Harbor	7,874.52
Total	8,919.79
Cost of rock for Plaquemine, La	276.80
Previous cost	15,879.90
Total	16,156.70
Cost of labor and services of boats for Plaquemine	144.78
Value of subsistence store transferred	173.02
Value of fuel transferred	210.00
Value of material transferred	1,238.24
Total	1,766.04

Very respectfully, your obedient servant,

G. ED. MOTT,
Assistant Engineer.

Lieut. JOHN MILLIS,
Corps of Engineers, U. S. A.

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NEW ORLEANS HARBOR.

The city of New Orleans, with its various suburbs, lies on both banks of the Mississippi River at a distance inland of 104 miles from the South Pass. This pass is the only one of the numerous mouths of the river having sufficient depth of water to admit seagoing vessels of deep draft, and it therefore is the entrance from seaward to the Mississippi River and the harbor of New Orleans. The city is the metropolis of the South, and besides being the most important seaport on the Gulf of Mexico, it stands first among the towns on the Mississippi in the commercial importance of its river traffic. It ranks seventh among the ports of the United States in the value of its imports, while in the value of its exports it is only exceeded by New York City.

The New Orleans Harbor, as at present developed, consists solely of a length of about 13 miles of the Mississippi River, which here has an average width of about 2,200 feet, and it comprises four comparatively straight reaches of various lengths and four curves or bends. Two of these bends, the one at Algiers Point and the one at Carrollton, are quite abrupt, the radius of curvature in the former being about equal to the width of the river, and the change in direction being more than 90°. The depth of the river is, in general, ample for the purposes of navigation.

The entire country in the vicinity is of alluvial formation and is consequently low and flat, being highest along the river bank and having a gentle slope back toward the swamps. During floods the river reaches a height of 5 or 6 feet above the highest ground in the city, and the levees, which are essential for the prevention of overflow, are as a rule necessarily built close to the river bank in order to meet the requirements of the various interests along the water front.

The construction of regular docks, or slips and piers, along the water front is as a rule impracticable, owing to the variation in height of water, the unstable nature of the banks, the swift current, and the tendency to deposit large quantities of silt. The water front is therefore occupied principally by continuous wharves, to which vessels must moor alongside; and since there are no good anchorage grounds, owing to the current and the great depth of water, the conditions generally in the harbor are such as to require an unusual development of water front to accommodate a given amount of shipping.

Although the condition of the river and of its banks here is one of comparative stability when contrasted with the extraordinary changes which often occur further upstream, the damage that results from even slight changes of the river in a port like New Orleans becomes serious. In general the action of the river is to erode or cut away and cause caving or sliding down of the banks in the concave shore at the bends and for some distance below them, resulting in the destruction of wharves, levees, streets, and sometimes of sheds and buildings. Where this action occurs on one bank a deposit of sediment and consequent shoaling and damage to the water front on the opposite shore usually takes place also. In certain localities similar destructive effects have been produced in the straight reaches also by the caving of the banks, due partly to the weight of masses of sediment deposited during high water, which when deprived by the falling river of the support which the water afforded during flood time, causes large portions of the bank to crack off and slide down. This action usually takes place only during falling water, but the destructive effects in the bends goes on to a greater or less extent at all stages of the water, and in addition to the immediate damage on the water front there is the danger of much more serious disaster resulting from the breaking of the levee during high water and the flooding of the city.

The object of the works of improvement in New Orleans Harbor is to check and if possible prevent the detrimental action of the river as above described, and to maintain the river bed and banks in a condition of permanency.

Under the approved project the work now in progress to accomplish the above objects, consists in the construction of submerged inclined spur dikes along the caving banks, which extend out normally to the bank line at intervals of from 500 to 1,600 feet.

Each spur dike rests on a wide mattress made of willows, brush, and timber, which is sunk in place by being loaded with stone, and which is intended to prevent any scouring action on the river bottom by eddies or local currents which may be produced by the dike. On this mattress the dike is built up by sinking successive layers of mattresses or cribs of diminishing widths, the construction of which is similar to that of the foot mattress, except that they are made thicker. The work is so planned that the top of the completed dike at the shore end will be below low-water line, and the crest of the dike has an approximately regular slope of about 3 horizontal to 1 vertical, its outer end resting on the river bottom in deep water. In the vicinity of wharves and docks the crest of the dike is placed low enough so it will not interfere with vessels; but in other localities the crest has been continued up to and

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united with the crest of the levee or the bank by an earth embankment paved with stone.

These structures are designed to check the velocity of the current along the shore, and thus diminish the erosion and caving of the bank, and cause deposit of sediment and the restoration of the bank line.

In certain localities their direct effect in bracing up the bank, and so preventing the caving which is liable to take place during the falling of the river, is also believed to be beneficial, at least locally.

When this form of structure is used, where the existing slope of the submerged portion of the river bank is not steep, the foot mattress probably becomes the most important part of the spur, and the dikes act more as an interrupted bank revetment.

The following work of improvement, in general accordance with the project as above outlined, had been done prior to July 1, 1891:

A continuous mattress, about 400 feet in length, had been placed just above the caving bank in Carrollton Bend, but this form of protection was afterwards abandoned.

Three spur dikes had been built in the Carrollton Bend, two in the Greenville Bend, six in the Gouldsboro Bend, and four in the Third District reach. Surveys to determine the condition of work already completed and for the preparation of plans for continuing the work had been made, and several of the barges and other portions of the plant had been repaired or extensively rebuilt.

All the completed work remained in place and served the purpose for which it was constructed, except that considerable local caving took place in Carrollton Bend, after the completion of Dikes 3, 4, and 5, and an eddy seemed to be formed between Dikes 4 and 5. A portion of the wharf and shed of the Louisville, New Orleans and Texas Railroad, at the head of Dike No. 4, was destroyed by the caving.

During the high-water season in March, 1891, a large crevasse occurred in the levee between the two dikes in the Greenville Bend, but so far as can be ascertained by soundings, no injury resulted to the dikes.

At the beginning of the year operations were resumed in the Third District reach, in accordance with the plan submitted in pursuance of the general project and approved by the Commission. Four spur dikes had been built in 1889, on the left bank near the Ursuline Convent. In this locality, and for some distance above, the levee is immediately on the river bank, and a street passes along parallel to the river and just back of the levee. In several places, caving had taken place, necessitating the construction of "run-arounds," or "horse-shoes," in the levee, projecting into the street. A complete interruption of the street and the ultimate destruction of buildings and wharves, was threatened. The project for continuing the work contemplated, building six more dikes, covering that portion of the river front between the uppermost of the dikes built in 1889, and Clouet street. These dikes were located opposite the points of the bank most threatened, and were to be built in the order that they seemed to be most urgently required to arrest the caving.

A quarterboat with a force of men and an outfit of tools was sent to the mouth of Thompsons Creek near Port Hudson to cut willows for the work. The force continued work at that point until October 11, 1891, when it was moved down to Profit Island. Willows were supplied both to the New Orleans Harbor work and to that at Plaquemine.

A sufficient quantity of rock for the immediate needs of the New Orleans Harbor work was on hand, stored on the bank near Southport, and a considerable amount of rock ballast was purchased in the harbor during the season; but toward the close of the season's work it became necessary to borrow 2,532 tons from that stored at Turnbull Island. This was afterwards returned at the expense of the New Orleans Harbor allotment.

Repairs to the quarterboat were not entirely complete at the beginning of work, and a vacant building in the Third District was rented for quarters and office accommodations.

Mattress and crib construction began July 23, and sinking of mattresses on Spur Dike No. 1 was commenced September 28. The dike was completed October 2, at a total field cost of $9,593.49. It contains 262,305.6 cubic feet of work.

Spur Dike No. 5 was next built. Sinking of mattress began October 13 and all mattresses and cribs were sunk by October 16. The field cost including cost of shore protection was $8,962.84. The total number of cubic feet of work was 202,449.6.

Spur Dike No. 2 was the next one undertaken. Sinking began October 30 and was finished November 5. Its field cost was $9,343.52, and it contains 253,713.36 cubic feet.

Spur Dike No. 3 was the last one built in this locality. Sinking began Septem-

ber 9 and was completed November 16. It contains 264,321.6 cubic feet of work, and the total field cost was $11,502.02.

Dikes 4 and 6 have not yet been built. The intervals between Dike 5 and Dike No. 1, of 1889, and that between Dikes 3 and 5 are greater than should exist if the caving and erosion were general and active along this front. The current is not very strong, however, and the sections of the river bottom show that the slope of the bank is not on an average much steeper than 3 base to 1 perpendicular. It is quite possible that the completed work will be sufficient to arrest the encroachment of the river and that the intermediate dikes will not be necessary.

After completing the four dikes in the Third District reach the plant was removed to Southport to continue work in the Carrollton Bend.

The caving that had taken place here since the completion of Dikes 3, 4, and 5, indicated that the intervals between the dikes was too great for this locality, where the curvature of the bank is such that the dikes, being normal to the bank line, may, perhaps, have sufficient convergence to increase the tendency of the water to form eddies or whirls in the intervals. In order to diminish the intervals and break up eddies, the Commission directed that two intermediate dikes, Nos. 3½ and 4½, be constructed, and that the gap between Dike No. 4 and the bank line which had formed by the caving be filled with a mattress. Dike No. 6 was also to be built if sufficient funds remained after completing the above.

Construction work in Carrollton Bend began November 19. Sinking of mattresses on Spur Dike No. 4½ began January 27, and the dike was completed January 30. The total field cost was $11,673.95, and the total cubic feet of work was 236,542.

Sinking of Spur Dike 3½ began February 13, and was finished February 16. The field cost was $11,941.38. The dike contains 297,342 cubic feet.

A mattress 80 feet by 90 feet and 2.16 feet thick was built and sunk at the head of Spur Dike No. 4 to connect it with the shore. Its cost was $716.16.

The long season of unusually low water and good weather was very favorable for the work, but during the latter part of the season the dikes in the Carrollton Bend were finished under much less favorable conditions, the river having risen, producing a swift current and much trouble from drift.

Serious caving in the vicinity of the French Market took place in October and November, and a survey of the bank and river bottom in the vicinity was ordered. It was found that the balance of the allotment available would not be sufficient to complete the construction work undertaken and the survey, and the Commission therefore approved the transfer of $8,000 from the allotment for the Red and Atchafalaya work to New Orleans Harbor.

The damage near the French Market was caused by settling of the river bank, and cracks appeared about 200 feet back from the outer crest of the bank or "levee" and the surface began to go down over a considerable area involving a large wharf, the tracks of the Louisville and Nashville and Southern Pacific Railroads, and a few small buildings. The settling was gradually progressive in amount and in superficial extent until it practically ceased about the middle of November. At that time it had extended along the river front for a distance of about 1,600 feet, between St. Ann and Esplanade streets, and its extreme width was about 250 feet.

Over the area affected there were several large cracks and the surface was quite uneven and broken, but the general settlement was from 5 to 10 feet. No noticeable change has taken place since and the portion occupied by the railroad tracks has been filled up and the levee restored.

In February a careful survey was made in the locality. Seven sections were sounded between St. Ann and Barracks street and map submitted. Three sections indicate that there has been in general a deepening of the river since the survey of 1878, but otherwise no material change has taken place. The slope of the bank at the cave is practically the same as it was in 1878 and does not average steeper than 3 base to 1 perpendicular. Borings made under direction of the city engineer of New Orleans showed a depth of about 50 feet of stiff clay, with an underlying stratum of sand of about the same thickness.

Erosion and caving still continue on the left bank from the completed work in Carrollton Bend down to Exposition Wharf, and during the past year the local authorities have built two new pieces of levee in anticipation of the destruction of the old levees in front. The upper levee extends from Leonidas street to Carrollton avenue and the lower to Exposition Wharf, beginning at Broadway street. These works necessitated the removal or abandonment of a large number of buildings and great loss of property.

A number of buildings were also thrown outside the new levee built during the year under direction of this office at Southport.

There has been no material change since the last report in the condition of the caving places in the vicinity of the Soraparu Market.

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NEW ORLEANS HARBOR.

Money statement.

July 1, 1891, balance unexpended			$69,719.54
Transferred from Red and Atchafalaya rivers allotment			8,000.00
			77,719.54
May 31, 1892, amount expended during fiscal year to date		$72,961.56	
Reimbursement by Capt. Dan. C. Kingman	$1.00		
Funds not called for by persons who have signed pay rolls	9.35		
		10.35	
			72,951.21
June 1, 1892, balance unexpended			4,768.33
In hand			4,768.33
Amount that can be profitably expended during the fiscal year ending June 30, 1894			200,000

The work in New Orleans Harbor has been under the immediate charge of Assistant Engineer William Garvin during the year. His report is as follows:

NEW ORLEANS, LA., *May 18, 1892.*

SIR: I have the honor to submit the following report on the work of improving the harbor at New Orleans, La.:

At date of last annual report, June 1, 1891, the condition of the work was as follows: The plant was at laying-up quarters at Exposition Wharf, all necessary repairs to barges had been completed, and seven of them were sent to the quarries on Ouachita River. New crib ways were being built and general preparations for the resumption of spur-dike construction were in progress. On July 20, 1891, the tug moved the plant from laying-up quarters to the Third District Bend. At this time the quarter-boat was on ways being repaired, and a house was rented to serve as office and quarters during the construction of the spur dikes in the Third District Bend.

On July 20 the steamer *General Newton* arrived with three barges of willows. The mattress for Spur No. 1, Third District Bend, was commenced July 23 and completed August 5, but owing to the barges being engaged transporting willows it was not sunk until September 28, fifty-four days after completion. The mattress was built in four sections, 100 by 120 feet each; the head block or upstream frame was built of 3 by 6 inch lumber, all other frames of 2 by 4 inch lumber, with stanchions or uprights 26 inches long and 5 feet between centers. The frames were spaced 10 feet between centers. They extend from bank out in stream or at right angles to the current. The first layer of brush was securely nailed to frames, the second, a thick layer, parallel to frames, and the third of selected willows placed across frames and spaced 2 feet distant. Lines of poles were placed across top of frames 20 feet distant to give additional strength and stiffness and to prevent rock shifting, there being but little current; few rods were used for strengthening frames at toggle pins.

The dimensions of the mattress were 120 by 400 by 2.16 feet, and the cost and material were:

633 cords of willows, at $1.9425	$1,229.60
18,250 feet, B. M., 2 by 4 inch lumber, at $11 per M	200.75
3,200 feet, B. M., 3 by 6 inch lumber, at $12 per M	38.40
348 tons of rock, at $2	696.00
1,200 pounds 6-inch steel wire nails, at 3 cents	36.00
700 pounds 9-inch steel wire nails, at 3½ cents	24.50
150 pounds 3½-inch steel wire nails, at 3.3 cents	4.95
1,007 pounds rods and mattress chain, at 3½ cents	35.24
1,000 pounds No. 10 galvanized wire, at 3.15 cents	31.50
24 fish plates, at 7 cents each	1.68
27 cords willow poles, at $3.25 per cord	87.75
Labor, superintendence, etc	1,809.58
Rations	120.85
Total	4,316.80

Number of cubic feet in mattress	104,001.60
Number of square feet in mattress	48,000
Pounds of rock per square foot to sink	14.50
Cost per square foot in place	$0.08993

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Crib construction was commenced August 5 and completed August 28. The first crib was sunk September 29 and the last October 2, 1891. The dimensions of the cribs built and sunk on this spur were:

	Cubic feet.
Crib No. 1, 340 by 40 by 6 feet	81,600
Crib No. 2, 308 by 28 by 6 feet	51,744
Crib No. 3, 260 by 16 by 6 feet	24,960
Total	158,304

The cost and material were:

755 cords of willow brush, at $1.9425	$1,466.58
56 cords of willow poles, at $3.25	182.00
25,500 feet, B. M., 3 by 6 inch lumber, at $12 per M	306.00
554 tons of rock, at $2	1,108.00
250 pounds No. 10 galvanized wire, at 3.15 cents	7.87
900 pounds 9-inch steel-wire nails, at 3½ cents	31.50
500 pounds 6-inch steel-wire nails, at 3 cents	15.00
100 pounds 3¼-inch steel-wire nails, at 3.3 cents	3.30
Subsistence	135.25
Labor, superintendence, etc	2,021.19
Total	5,276.69

Number of cubic feet of crib work in spur	158,304
Pounds of rock per cubic foot to sink	6.998
Cost per cubic foot in place	$0.0333
Total cost of the spur was	$9,593.49

Construction of Spur No. 5.—Mattress work was commenced August 5, completed August 20, and sunk October 13, being fifty-four days after completion. The style of mattress was the same as on Spur No. 1, and its dimensions were 120 by 40 by 2.16 feet. The cost and material were:

633 cords of willow brush, at $1.9425	$1,229.60
18,250 feet, B. M., 2 by 4 inch lumber, at $11 per M	200.75
3,200 feet, B. M., 3 by 6 inch lumber, at $12 per M	38.40
348 tons of rock, at $2	696.00
1,200 pounds steel-wire nails, at 3 cents	36.00
700 pounds 9-inch steel-wire nails, at 3½ cents	24.50
200 pounds 3¼-inch steel-wire nails, at 3.3 cents	6.60
501 pounds rods and mattress chain, at 3½ cents	17.53
750 pounds No. 10 galvanized wire, at 3.15 cents	23.62
8 fish plates, at 7 cents each	.56
27 cords willow poles, at $3.25	87.75
Labor, superintendence, etc	1,825.50
Subsistence	125.25
Total	4,312.06

Number of cubic feet in mattress	104,001.6
Number of square feet in mattress	48,000
Pounds of rock per square foot to sink	14.50
Cost per square foot in place	$0.08983

Crib construction was commenced August 28 and completed September 15. The first crib was sunk October 14 and the last October 16. The dimensions of the cribs built and sunk on this spur were:

	Cubic feet.
Crib No 1, 90 by 40 by 6 feet	21,600
Crib No. 2, 286 by 28 by 6 feet	48,048
Crib No. 3, 300 by 16 by 6 feet	28,800

The cost and material were:

545 cords willow brush, at $1.9425	$1,058.66
56 cords willow poles, at $3.25	182.00
17,460 feet, B. M., 3 by 6 inch lumber, at $12 per M	209.52
353 tons of rock, at $2	706.00
450 pounds No. 10 galvanized wire, at 3.15 cents	13.17
700 pounds 9-inch steel-wire nails, at 3½ cents	24.50
400 pounds of 6-inch steel-wire nails, at 3 cents	12.00
100 pounds 3¼-inch steel-wire nails, at 3.3 cents	3.30

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Labor, superintendence, etc	$1,699.79
Subsistence	135.00
Total	4,043.94

Number of cubic feet of crib-work	98,448
Pounds of rock per cubic foot to sink	7.171.00
Cost per cubic foot in place	$0.04107.00
Total cost of the subaqueous portion of the spur was	$8,356.00

Shore protection.—This consists of an earthen spur or levee, protected by a covering or pavement of rock; this covering extends 50 feet above and 70 feet below, to form aprons and practically prolong the foundation mattress to the main levee. The ultimate result is a continuous spur commencing above high-water mark instead of at low.

The cost and material were:

100 tons of rock, at $2	$200.00
75.5 tons of trash rock, at 75 cents	56.62
Labor	350.22
Total	606.84
The total cost of the spur was	8,962.84

Spur No. 2.—Construction of the mattress was commenced August 20 and completed August 29; it was sunk October 30, being sixty-two days after completion. The style of mattress was the same as on Spur No. 1, and its dimensions were 120 by 400 by 2.16 feet thick.

The cost and material were:

633 cords willow brush, at $1.9425	$1,229.60
27 cords willow poles, at $3.25	87.75
384 tons of rock, at $2	768.00
18,250 feet, B. M., 2 by 4 inch lumber, at $11 per M	200.75
3,200 feet, B. M., 3 by 6 inch lumber, at $12 per M	38.40
900 pounds 9-inch steel-wire nails, at 3½ cents	31.50
1,400 pounds 6-inch steel-wire nails, at 3 cents	42.00
200 pounds 3½-inch steel-wire nails, at 3.3 cents	6.60
1,000 pounds No. 10 galvanized wire, at 3.15 cents	31.50
452 pounds iron rods, mattress chains, etc., at 3½ cents	15.82
Labor, superintendence, etc	1,840.25
Subsistence	120.00
Total	4,412.17

Number of cubic feet in mattress	104,001.6
Number of square feet in mattress	48,000
Pounds of rock per square foot to sink	16
Cost per square foot in place	$0.09192

Crib construction commenced September 15 and completed October 5. The first crib was sunk November 2 and the last November 5.

The dimensions of cribs built and sunk on this spur were:

	Cubic feet.
Crib No. 1, 345 by 40 by 6 feet	82,800
Crib No. 2, 276 by 28 by 6 feet	46,368
Crib No. 3, 214 by 16 by 6 feet	20,544
Total	149,712

The cost and material were:

574 cords willow brush, at $1.9425	$1,114.99
56 cords willow poles, at $3.25	182.00
405 tons rock, at $2	810.00
26,940 feet, B. M., 3 by 6 inch lumber, at $12 per M	323.28
1,400 pounds 9-inch steel-wire nails, at 3½ cents	49.00
700 pounds 6-inch steel-wire nails, at 3 cents	21.00
100 pounds 3½-inch steel-wire nails, at 3.3 cents	3.30
500 pounds No. 10 galvanized wire, at 3.15 cents	15.75
Labor, superintendence, etc	1,814.08
Subsistence	145.25
Total	4,478.65

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Number of cubic feet of crib-work	149,712
Pounds of rock per cubic foot to sink	5.41
Cost per cubic foot in place	$0.02991
Total cost of the subaqueous portion of the spur was	$8,890.82

Shore protection.—The cost and material were:

184.2 tons rock, at $2	$368.40
Labor	84.30
Total for shore work	452.70
Total cost of spur was	9,343.52

Spur No. 3.—Construction of the mattress was commenced September 9, completed September 25, and was sunk November 10, being forty-six days after completion. The dimensions of the mattress were 120 by 400 by 2.16 feet thick, and the cost and material were:

511 cords willow brush, at $1.9425	$992.61
27 cords willow poles, at $3.25	87.75
374 tons rock, at $2	748.00
18,250 feet, B. M., 2 by 4 inch lumber, at $11 per M	200.75
3,200 feet, B. M., 3 by 6 inch lumber, at $12 per M	38.40
900 pounds 9-inch steel-wire nails, at 3½ cents	31.50
1,400 pounds 6-inch steel-wire nails, at 3 cents	42.00
200 pounds 3½-inch steel-wire nails, at 3.3 cents	6.60
1,000 pounds No. 10 galvanized wire, at 3.15 cents	31.50
685 pounds iron rods and mattress chain, at 3½ cents	23.97
Labor, superintendence, etc	1,838.42
Subsistence	130.00
Total cost of mattress	4,171.50

Number of cubic feet in mattress	104,001.6
Number of square feet in mattress	48,000
Pounds of rock per square foot to sink	15.583
Cost per square foot in place	$0.08690

The dimensions of the cribs built and sunk on this spur were:

	Cubic feet.
Crib No. 1, 362 by 40 by 6 feet	86,880
Crib No. 2, 300 by 28 by 6 feet	50,400
Crib No. 3, 240 by 16 by 6 feet	23,040

The construction of the cribs was commenced October 5; completed November 7. The first crib was sunk November 12 and the last November 16. The cost and material were:

932 cords willow brush, at $1.9425	$1,810.41
56 cords willow poles, at $3.25	182.00
684 tons rock, at $2	1,368.00
27,606 feet, B. M., 3 by 6 inch lumber, at $12 per M	331.27
1,400 pounds 9-inch steel-wire nails, at 3½ cents	49.00
700 pounds 6-inch steel-wire nails, at 3 cents	21.00
50 pounds 3½-inch steel-wire nails, at 3.3 cents	1.65
550 pounds No. 10 galvanized wire, at 3.15 cents	17.32
100 pounds iron rods, at 3½ cents	3.50
Labor, superintendence, etc	2,584.56
Subsistence	209.50
Total	6,578.21

Number of cubic feet of crib-work	160,320
Pounds of rock per cubic foot to sink	8.532
Cost per cubic foot in place	$0.04103
Total cost of the subaqueous portion of the spur was	$10,749.71

On shore protection the cost and material were:

210.77 tons rock, at $2	$421.54
26.41 tons trash rock, at 75 cents	19.80
Labor	310.97
Total	752.31
Total cost of the spur was	11,502.02

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The completion of Spur No. 3 in the Third District Front finished all work in that locality for the present. The weather during the progress of this work was very favorable. The only difficulty experienced was from heavy south winds and rough river, which delayed the sinking several days, but did not interfere with construction work. During one of these gales the barge with mattress ways was sunk, the barge being completely rotten and worthless; the ways and good timber were removed and the hull abandoned.

On November 17, immediately on completion of the spurs in the Third District Front, all available barges were sent to Plaquemine for use in sinking spur dikes in that locality, and preparations for work in the Southport Bend were commenced. These preparations consisted chiefly in loading on barges all material left on hand, moving office and other furniture from house to quarter-boat, moving and mooring the plant in the new locality.

New mattress ways had been constructed to replace those sunk in Third District Front, and the construction of the mattress for Spur No. 3½ was commenced November 19. This mattress was the first built, but was not sunk until after the mattress on Spur No. 4½.

Spur No. 4½, Southport Bend.—The construction of the mattress was commenced December 8, completed December 23, and was sunk January 27, 1892. The style of mattress was the same as that built and sunk in the Third District Bend. It extends 60 feet above and 90 feet below center line. The cost and material were:

593 cords willow brush, at $1.9425	$1,151.90
20.5 cords willow poles, at $1.9425	39.82
411 tons rock, at $3.50	1,438.50
29,085 feet, B. M., 2 by 4 inch lumber, at $10 per M	290.85
3,200 feet, B. M., 3 by 6 inch lumber, at $11 per M	35.20
1,600 pounds 6-inch steel-wire nails, at 2.20 cents	35.20
925 pounds 9-inch steel-wire nails, at 2.75 cents	25.43
75 pounds 3½-inch steel-wire nails, at 2.55 cents	1.91
125 pounds 4½-inch steel-wire nails, at 2.55 cents	3.18
1,000 pounds No. 10 galvanized wire, at 3 cents	30.00
1,336 pounds iron rods and mattress chain, at 3½ cents	46.76
17 fish plates, at 7 cents each	1.19
Labor, superintendence, etc	2,109.00
Subsistence	486.70
Total	5,695.64

Number of cubic feet in mattress	130,000
Number of square feet in mattress	60,000
Pounds of rock per square foot to sink	13.7
Cost per square foot in place	$0.09492

Crib construction was commenced November 28, 1891; completed January 5, 1892. The first crib was sunk January 28, and the last January 30. The dimensions of the cribs built and sunk on this spur were:

	Cubic feet.
Crib No. 1, 70 by 70 by 6 feet	29,400
Crib No. 2, 52 by 120 by 6 feet	37,440
Crib No. 3, 34 by 275 by 6 feet	56,100
Crib No. 4, 16 by 350 by 6 feet	33,600
Total	156,540

The cost and material were:

628 cords willow brush, at $1.9425	$1,219.89
518 tons rock, at $3.50	1,813.00
28,666 feet, B, M., 3 by 6 inch lumber, at $11 per M	315.32
1,600 pounds 9-inch steel-wire nails, at 2.75 cents	44.00
700 pounds 6-inch steel-wire nails, at 2.20 cents	15.40
943 pounds No. 10 galvanized wire, at 3 cents	28.29
Labor, superintendence, etc	2,048.89
Subsistence	493.52
Total	5,978.31

Number of cubic feet of crib-work	156,540
Pounds of rock per cubic foot to sink	6.618
Cost per cubic foot in place	$0.03819
Total cost of the spur was	$11,673.95

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Spur No. 3½, Southport Bend.—Construction of the mattress was commenced November 19 and completed December 7, 1891, and was sunk February 13, 1892. The dimensions of the mattress were 150 by 400 by 2.16 feet. The cost and material were:

593 cords willow brush, at $1.9425	$1,151.90
20.5 cords willow poles, at $1.9425	39.82
426 tons rock, at $3.50	1,491.00
29,085 feet, B. M., 2 by 4 inch lumber, at $10 per M	290.85
3,200 feet, B. M., 3 by 6 inch lumber, at $11 per M	35.20
925 pounds 9-inch steel-wire nails, at 2.75 cents	25.43
1,600 pounds 6-inch steel-wire nails, at 2.20 cents	35.20
75 pounds 3½-inch steel-wire nails, ar 2.55 cents	1.91
125 pounds 4½-inch steel-wire nails, at 2.55 cents	3.18
1,000 pounds No. 10 galvanized wire, at 3 cents	30.00
705 pounds iron rods and chain, at 3¾ cents	26.25
53 fish plates, at 7 cents each	3.71
250 feet galvanized wire line, at 12½ cents per foot	31.25
Labor, superintendence, etc	2,129.52
Subsistence	509.02
Total	5,804.24

Number of cubic feet in mattress	130,002
Number of square feet in mattress	60,000
Pounds of rock per square foot to sink	14.2
Cost per square foot in place	$0.09673

Crib construction was commenced December 31, 1891; completed January 18, 1892. The first crib was sunk February 14, and the last February 16, 1892. The dimensions of the cribs built and sunk on this spur were:

	Cubic feet.
Crib No. 1, 70 by 100 by 6 feet	42,000
Crib No. 2, 52 by 170 by 6 feet	53,040
Crib No. 3, 34 by 225 by 6 feet	45,900
Crib No. 4, 16 by 275 by 6 feet	26,400
Total	167,340

The cost and material were:

680 cords willow brush, at $1.9425	$1,320.90
451 tons rock, at $3.50	1,578.50
26,176 feet, B. M., 3 by 6 inch lumber, at $11 per M	287.93
1,600 pounds 9-inch steel-wire nails, at 2.75 cents	44.00
900 pounds 6-inch steel-wire nails, at 2.20 cents	19.80
943 pounds No. 10 galvanized wire, at 3 cents	28.29
Labor, superintendence, etc	2,324.52
Subsistence	533.20
Total	6,137.14

Number of cubic feet crib-work	167,340
Pounds of rock per cubic foot to sink	5.396
Cost per cubic foot in place	$0.03667
Total cost of the spur was	$11,941.38

Between the sinking of Spur No. 4½ and 3½, eight days were lost, it being impossible to place the barges in position, owing to the heavy flow of driftwood.

A mattress 80 by 90 by 2.16 feet was built and sunk at the head of Spur No. 4, Southport Bend. This mattress was sunk to connect the foundation mattress with the present low-water bank line, the caving having worked upstream to within 10 feet of the center line. The construction was commenced December 24, completed December 28, 1891, and sunk January 8, 1892. The cost and material were:

74 cords willow brush, at $1.9425	$143.74
68 tons rock, at $3.50	238.00
2,900 feet, B. M., 2 by 4 inch lumber, at $10 per M	29.00
660 feet, B. M., 3 by 6 inch lumber, at $11 per M	7.26
200 pounds 6-inch steel-wire nails, at 2.2 cents	4.40
150 pounds 9-inch steel-wire nails, 2.75 cents	4.12
50 pounds 3½-inch steel-wire nails, at 2.55 cents	1.27
150 pounds No. 10 galvanized wire, at 3 cents	4.50
97 iron rods at 3½ cents	3.39

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3 fish plates at 7 cents each	$0.21
Labor, superintendence, etc	243.57
Subsistence	37.20
Total	716.66
Number of square feet in mattress	7,200
Pounds of rock per square foot to sink	18.888
Cost per square foot in place	$0.09953

The total cost and material for the four spur dikes built in the Third District Front were:

5,216 cords brush, at $1.9425	$10,132.08
332 cords poles, at $3.25	1,079.00
3,944.97 tons rock, at $2	7,889.94
73,000 feet, B. M., 2 by 4 inch lumber, at $11 per M	803.00
110,306 feet, B. M., 3 by 6 inch lumber, at $12 per M	1,323.67
7,600 pounds 9-inch steel-wire nails, at 3½ cents	266.00
7,500 pounds 6-inch steel-wire nails, at 3 cents	225.00
1,100 pounds 3½-inch steel-wire nails, at 3.3 cents	36.30
5,500 pounds No. 10 galvanized wire, at 3.15 cents	173.25
2,745 pounds iron rods and mattress chain, at 3½ cents	96.07
32 fish plates, at 7 cents each	2.24
101.91 tons trash rock, at 75 cents	76.43
Labor, including tug, superintendence, etc	16,178.86
Subsistence	1,120.60
Total	39,402.44
Total number of cubic feet of mattress work	416,006.4
Total number of square feet of mattress work	192,000
Total number of cubic feet of crib-work	566,784
Average cost of mattress work per square foot	$0.08964
Average cost of crib work per cubic foot	$0.03595

In calculating the average cost of crib and mattress work the cost of spur levee and paving was not considered.

The total cost and material for the two spur dikes and mattress for head of Spur No. 4, Southport Bend, were:

2,568 cords brush, at $1.9425	$4,988.34
41 cords poles, at $1.9425	79.64
1,874 tons rock, at $3.50	6,559.00
61,070 feet, B. M., 2 by 4 inch lumber, at $10 per M	610.70
61,902 feet, B. M., 3 by 6 inch lumber, at $11 per M	680.92
5,200 pounds 9-inch steel-wire nails, at 2.75 cents	143.00
5,000 pounds 6-inch steel-wire nails, at 2.2 cents	110.00
250 pounds 4½-inch steel-wire nails, at 2.55 cents	6.37
200 pounds 3½-inch steel-wire nails, at 2.55 cents	5.10
4,036 pounds No. 10 galvanized wire, at 3 cents	121.08
2,183 pounds iron rods and mattress chain, at 3½ cents	76.40
73 fish plates, at 7 cents each	5.11
250 feet ⅝-inch galvanized-wire line, at 12½ cents	31.25
Labor, including tug, superintendence, etc	8,855.50
Subsistence	2,059.64
Total	24,332.05
Total number of cubic feet of mattress work	275,604.2
Total number of square feet of mattress	127,200
Total number of cubic feet of crib-work	323,880
Average cost of mattress work per square foot	$0.09604
Average cost of crib-work per cubic foot	$0.03740

There has been built and sunk during this season a total of 319,200 square feet of mattress-work and 690,664 cubic feet of crib-work, at a total cost of $63,733.86.

On completion of the two spurs in the Southport Bend the river had risen to a stage that prevented further work. The willows on hand were unloaded on the bank, and the plant was moved to laying-up quarters at Exposition Wharf.

The quarter-boat was repaired at a total cost of $7,077.52. This repair consisted of an entire new hull, some minor repairs to house, and painting of house and hull. Of this, $1,405.25 for labor and $544 for material were included in my report of June 1,

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1891. Since that date there was expended for labor $4,177.94 and for material $950.33, making a total of $5,583.19 for labor and $1,494.33 for material.

The tug *Tilda* has been docked twice, once to renew wheel and once to repair hull. The cost of tug was:

Pay of crew, with subsistence	$2,777.71
Fuel, 5,232.5 barrels coal	2,370.79
Permanent property	277.31
Expendable material, docking, and repairs	607.15
Total	6,032.96
Amount charged to spur-dike construction	4,174.42
Amount charged to care of plant	974.08
Amount charged to repair tug	607.15
Permanent property	277.31
Total	6,032.96

Launch No. 5 had extensive repairs to boiler and machinery, new roof and fender streak, hull scraped, painted, cemented, and other minor repairs. The cost was:

Pay of crew and labor for repairs	$599.24
Fuel, 209 barrels coal	98.90
Bills of machinist and material	407.34
Permanent property	5.60
Total	1,111.08
Amount charged to repairs	717.36
Amount charged to surveys	271.80
Amount charged to miscellaneous	116.32
Permanent property	5.60
Total	1,111.08

The launch *Alaska* was engaged with survey party for awhile and cost for crew and fuel $88.37. During her service with Assistant Engineer Hardee she was docked at the New Orleans Harbor Works and had her hull scraped and painted and a new propeller wheel put on, which cost, exclusive of bill of machinist, $40.65.

Barge No. 5 is being repaired. It has cost to date $51.30 for labor. The repairs to this barge will consist of entire new sides, head blocks, and rakes.

The tug *Comstock* arrived at the plant from Plaquemine a short time previous to completion of work at Southport Bend, and was engaged for awhile in miscellaneous work for the New Orleans Harbor, for which she cost for labor and fuel $251.25. Her hull was very rotten, and authority was asked and granted to repair her. She is now in dock and has cost to the present time for labor $1,657.54 and for material $603.32, making a total of $2,260.86. This tug has been in service at the Atchafalaya and Plaquemine works, and the repairs will be charged to those works.

The dredge *Pah-Ute* was docked in the Woods Dock at Algiers and cost $236 for dockage. There has been expended for labor, watchmen, etc., $114, making a total of $350.

A barge was purchased and fitted up to be used in docking tugs and other small boats in the service. The repairs to this barge consisted of patching and building up the old sides, strengthening bottom with additional floor timbers, side braces, and four fore-and-aft gunwales drift-bolted to floor timbers, building gate in end, calking, and pitching. The cost was for barge $125, material $114.75, and for labor $471.36, making a total of $711.11. This dock is in fair condition and will stand a couple of years' service.

Mattress ways were built for work in the Southport Bend. The cost was for material $179.50 and for labor $278.52, making a total of $458.02. These ways were superior in quality and buoyancy to any previously built. Material on hand to be used for spur-dike construction:

5,859 pounds iron rods, at 3½ cents	$205.06
13,500 feet, B. M., 2 by 4 inch lumber, at $11 per M	148.50
24,326 feet, B. M., 3 by 6 inch lumber, at $12 per M	291.91
739 cords willow brush, at $1.9425	1,435.50
Total	2,080.67

The total value of property and tools lost and destroyed during the season's work was $7,194, not including the crib ways that were lost at Southport or the old mat-

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tress barge lost in the third district. The mattress ways have been replaced and cost given in this report. The crib ways can be replaced at a cost of $350.

Surveys and gauges.—Surveys have been made in the third district, Gouldsboro, Greenville, and Southport bends also at the caving bank near the French Market. The total cost was $994.60.

The wreck of an old dry dock lying at Point Celeste has been destroyed at a cost of $172 for powder and caps.

Gauge staffs have been furnished to the different stations at a total cost of $101.86.

Since the completion of spur-dike construction the tug *Tilda* has been engaged on levees and towing barges to quarries.

All available barges have been engaged transporting rock from quarries to Plaquemine and Turnbull Island.

Very respectfully, your obedient servant,

WILLIAM GARVIN,
Assistant Engineer.

Lieut. JOHN MILLIS,
Corps of Engineers, U. S. A.

LEVEES.

The levee system in this district is continuous on the west bank down to a point just above the "Jump," about 11 miles above the head of the Passes, with the exception of a gap of about 26 miles between Bougere and the mouth of Red River. Opposite this gap the strip of cultivated land along the river bank is very narrow, the slope back toward the swamps is greater than it is above, and the land is subject to overflow by water from the Lower Red, which is unleveed, as well as by that from the Mississippi.

On the east bank the line of bluffs is approximately parallel to the course of the river from Vicksburg down to Baton Rouge, and at no point are the bluffs at any great distance from the river bank. There are many detached private levees in this part of the district designed to keep the river from overflowing the bottom lands between the river and the bluffs, but there is no continuous system of levees, nor is such a system needed.

At Baton Rouge the river leaves the bluffs and the levee system of the east bank begins and continues down to Fort St. Philip, about 21 miles above the head of the Passes. Measured by the line of the river channel there are in the district about 415 miles of continuous levee on the west bank and 206 miles on the east bank.

There are, besides, more or less complete levee systems in the State of Louisiana on the Red, Black, Ouachita, Bœuf, Tensas, and Atchafalaya rivers; on Bayous Macon, Des Glaise, Plaquemine, and Lafourche, and on several smaller streams and bayous. It is estimated that the State now contains a total of about 1,100 miles of effective levees.

Up to July 1, 1890, the following-named Mississippi River levees in this district had been built in whole or in part, enlarged, or extensively repaired by the United States, and were generally known as United States levees:

Name of levee.	Below Cairo.	Right or left bank.	Approximate length.
Above Red River.	*Miles.*		*Miles.*
Point Pleasant	624	Right	5
Hard Times-Wilson	631	....do	10.2
Hard Times	633	....do	.8
Evergreen	636	....do	2
Hardscrabble and Bondurant	640	....do	5.2
Kempe	659	....do	3.9
Lake Concordia	693	....do	18.5
Greens to Fairview	722	....do	11
Total			56.6
Below Red River.			
Atchafalaya River to Red River Landing	762	Right	6
Red River Landing downstream	766	....do	1
Hog Point to Raccourci	767½	....do	3.2
Raccourci Crevasses	784	....do	1.1
Morganza	789	....do	1.3
Stewart	791½	....do	.3
Point Coupée	797	....do	1.1
Bonnet Carré	927	Left	2.4
Total			16.4
Total in district			73.0

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The above does not include levees built by the United States and afterwards abandoned or thrown out of the main line by construction of new lines behind them, as was rendered necessary by crevasses or changes in the river bank, but only comprises the approximate length of embankment that could then be considered as effective levee or capable of being made so by restoring breaks.

It will be observed that by far the greater portion of these levees were on the Tensas Basin or above the mouth of Red River on the west bank, and that with the exception of rendering assistance to close the Bonnet Carré crevasse the Federal Government had undertaken no levee building below Baton Rouge prior to 1890.

The disastrous flood of 1890, which, in many places, was unprecedented in the height to which the water rose, left the levee system of the district in a damaged and weakened condition with many crevasses, and since that date Federal aid in restoring, strengthening, and completing the system has been extended to all parts of the district except that below New Orleans. Assistance has also been given in maintaining the levees during high water.

The following table shows the total amount that has been made available by allotment and transfer for the construction, repair, and protection of levees in the various subdivisions of this district since the act of September 19, 1890:

Levees, Tensas Basin	$256,873.25
For protection of same during high water	15,202.75
Total	272,076.00
Levees, right bank, below Red River	179,447.40
For protection of same during high water	9,444.60
Total	188,892.00
Levees, left bank, below Red River	119,156.60
For protection of same during high water	6,959.40
Total	126,116.00

Recapitulation.

Amount allotted from the act of September 19, 1890, for levees, Fourth district	$555,477.25
For protection of levees, Fourth district	31,606.75
Grand total	587,084.00

The above allotments have been applied in accordance with the approved recommendations of the board of officers on building and repairing levees, consisting of the three officers in charge of districts, as follows:

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Statement of levees built by the United States from July 1, 1890, to June 30, 1892, giving in detail location, quantity, price, and total cost of each levee.

Levee.	Distance below Cairo.	Number of cubic yards.	Price per cubic yard.	Total cost of levee.
Tensas Basin.				
	Miles.		*Cents.*	
Bedford	606 R.	43,738.18	20.3	$8,860.85
Hardscrabble	639 R.	193,849.39	22.98	44,546.58
Kempe (1890)	659 R.	38,489.71	23	9,744.53
Kempe, upper section	659 R.	98,157.44	23.79	23,351.65
Kempe, middle section	659 R.	68,887.67	14.98	10,319.36
Kempe, lower section	659 R.	34,948.72	14.45	5,050.09
Gibson Landing	683.5 R.	338,200.91	19⅜	*74,996.47
Ferriday	693 R.	72,472.03	17	15,144.13
Ferriday Crevasse	693 R.	3,987.78	18½	737.74
Arnauldia	702 R.	3,289.11	17	559.15
Henderson	713 R.	34,125.43	23	7,848.85
Deer Park	722.5 R.	99,628.85	17¾	17,624.12
Total	....	1,029,775.22	....	218,783.52
Right bank, below Red River.				
Nina (1890)	806.5 R.	88,037.41	18	†15,596.74
Nina (gap) 1892	806.5 R.	8,840.78	20	1,768.16
Highland	815.5 R.	127,895.96	23.74	30,551.07
Highland Extension	815.5 R.	199,136.35	15.5	30,866.13
Barroza	823 R.	164,860.69	26.99	46,713.05
Mayflower-Union	853 R.	60.636.65	14⅞	9,019.70
Fortville	855 R.	65,814.01	13.44	8,845.41
Evergreen	857 R.	93,654.73	19	17,794.40
Dunboine	865 R.	7,468.29	15.98	1,193.43
Total	....	816,344.87	....	162,348.09
Left bank, below Red River.				
Shannon	837 L.	77,136.00	18¼	14,077.32
Martinez	842 L.	4,452.00	18¼	812.49
Gay to Hollywood	845 L.	39,428.00	18	7,097.04
Woodstock	847.5 L.	29,182.00	17.99	5,249.84
Hermitage	850 L.	24,218.00	16¾	4,056.51
Grenada to Mount Olive	855.5 L.	17,602.00	18	3,168.36
Southwood	875.5 L.	62,942.00	18.45	11,612.80
Southwood Extension	875.5 L.	124,627.93	15½	19.317.32
Ashland to Linwood	878 L.	11,230.00	20	2,246.00
Dicharry	882 L.	75,145.00	19⅞	14,935.07
Irvine	892.5 L.	9,759.00	18	1,756.62
Union	893.5 L.	10,507.00	18	1,891.26
Lilly	900.5 L.	22,900.00	19.99	4,577.71
College Point-St. Michael	903.5 L.	7,417.00	17.99	1,334.32
Tessier-Bourgeois	909.5 L.	23,524.66	16.98	3,994.49
Terre Haute to Hope	919.5 L.	15,899.00	18	2,860.92
Cornland	922 L.	14,486.00	18.97	2,748.00
Destrahan	939 L.	3,052.70	16.99	518.65
Freilsen to Almedia	942.5 L.	6,521.30	16.99	1,109.97
Southport	955.5 L.	17,758.97	16	2,841.44
Total	....	597,788.56	....	106,206.13

* Payment for overhaul and extra work, amounting to $9,470.04, included in total.

† Samuel L. James, jr., contractor; $250 were reserved under supplementary contract dated June 20, 1891; this contract was annulled January 23, 1892, and work was completed in open market by James R. Marlow.

Recapitulation of expenditures for the construction of new levees from July 1, 1890, to June 30, 1892.

Levees, Tensas Basin	$218,783.52
Levees, right bank, below Red River	162,348.09
Levees, left bank, below Red River	106,206.13
Total	487,337.74
Average price per cubic yard:	Cents.
Levees, Tensas Basin	21.245
Levees, right bank, below Red River	19.89
Levees, left bank, below Red River	17.76
General average cost per cubic yard	19.94

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Abstract of proposals received in response to advertisement dated September 8, 1891, for construction of levees in the fourth district, Mississippi River, opened September 23, 1891.

TENSAS BASIN.

[Price per cubic yard.]

No.	Name and address of bidder.	Hardscrabble (639 R), about 104,000 cubic yards.	Kempe, upper section (659 R), about 98,500 cubic yards.	Kempe, middle section (659 R), about 68,000 cubic yards.	Kempe, lower section (659 R), about 33,700 cubic yards.
		Cents.	*Cents.*	*Cents.*	*Cents.*
1	Carey & Bradburn, Marshall, Tex	*22.98	*23.79	*14.98	14.74
2	T. A. Helgason, Natchez, Miss				*14.45
3	Gibson & Deaton, Greenville, Miss	32	29.50	16.95	14.98
4	Keogh, Moore & Co., St. Louis, Mo			17.50	14.99
5	J. N. Ogden, Baton Rouge, La				16.90
6	A. Eltringham, Natchez, Miss			16.97	14.95
7	Robert Johnson, Memphis, Tenn	28½	27½	17½	16
8	Augustus P. Martin, Waterproof, La		41	19	17½
9	Manning & Howe, Pittsburg, Pa				16
10	Thomas O'Malley Imp. Co., Baton Rouge, La	26½	26½	26½	26½
11	Ernest Hyner, Greenville, Miss	25.94			
12	John Bavonset, New Orleans, La				16.24
13	Andrews Bros. Const. Co., Baton Rouge, La	30.49	32.44	18.99	15.44
14	Jeffries & Dameron, Memphis, Tenn	34	38	22	17

RIGHT BANK BELOW RED RIVER.

No.	Name and address of bidder.	Highland Extension (815.5 R), about 220,000 cubic yards.	Eliza (844 R), about 30,500 cubic yards.	Mayflower-Union (853 R), about 30,100 cubic yards.	Dunboine (865 R), about 7,500 cubic yards.
		Cents.	*Cents.*	*Cents.*	*Cents.*
1	John Scott & Son, St. Louis, Mo	*15½			
2	Israel R. Babbitt, Baton Rouge, La		15.9	15.9	17
3	Noble W. Irish, Carlisle, Ill			*14⅞	
4	Gibson & Deaton, Greenville, Miss	19		16.97	*15.98
5	Homan, McFadden & Cassidy, St. Gabriel, La			15.96	20
6	J. N. Ogden, Baton Rouge, La	17.90		16.9	
7	A. Eltringham, Natchez, Miss	17.48		17.23	
8	Don B. Hearrin, Baton Rouge, La			16⅞	
9	Robert Johnson, Memphis, Tenn	18½			
10	Thomas O'Malley Imp. Co., Baton Rouge, La	27½	24	24	24
11	Ernest Hyner, Greenville, Miss			20	
12	John Bavouset, New Orleans, La	16.44		16.98	
13	Andrews Bros. Const. Co., Baton Rouge, La	17.24			
14	Jeffries & Dameron, Memphis, Tenn	17½	16½	17	17½

LEFT BANK BELOW RED RIVER.

No.	Name and address of bidder.	Southwood Extension (875.5 L), about 129,000 cubic yards.	Tessier-Bourgeois (909.5 L), about 19,400 cubic yards.	Southport (955.5 L), about 17,500 cubic yards.
		Cents.	*Cents.*	*Cents.*
1	Gibson & Deaton, Greenville, Miss	17.98	*16.98	
2	Keogh, Moore & Co., St. Louis, Mo	15½		
3	Louis Le Sassier, New Orleans, La			*16
4	Kilpatrick & Storer, New Orleans, La	18		
5	Homan, McFadden & Cassidy, St. Gabriel, La	17.9		
6	J. N. Ogden, Baton Rouge, La	17.97	20	25
7	A. Eltringham, Natchez, Miss	17.48		
8	Thomas O'Malley Imp. Co., Baton Rouge, La	22	23	23
9	Ernest Hyner, Greenville, Miss	18		
10	John Bavouset, New Orleans, La	17.19		
11	Andrews Bros. Const. Co., Baton Rouge, La	17.74		21
12	Jeffries & Dameron, Memphis, Tenn	19½		

*Bids marked thus (*), are the lowest received, were accepted, and contracts entered into.

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Abstract of proposals received in response to advertisement by poster, dated September 26, 1891, for construction of Fortville Levee, near Plaquemine, Louisiana.

No.	Name and address of bidder.	Price per cubic yard.*	Total.
		Cents.	
1	Andrew Brothers Construction Company, Baton Rouge, La	13.44	$7,392.00
2	John Bavouset, Dalcour, La	14.46	7,953.00
3	Jeffries & Dameron, Memphis, Tenn	14¾	8,112.50
4	Homan, McFadden & Cassidy, St. Gabriel, La	15.9	8,745.00
5	P. J. Coffman, Napoleonville, La	17½	9,625.00
6	Michel Walsh, Plaquemine, La	17.99	9,894.50
7	S. Bowman Burbank, Cofield, La	19½	10,725.00

*About 55,000 cubic yards.

The bid of Andrews Brothers Construction Company (No. 1) being the lowest, was accepted and contract entered into. Amount available for this levee, $8,500.

Abstract of proposals received in response to advertisement by poster dated October 14, 1891, for construction of Ferriday Crevasse Levee.

No.	Name and address of bidder.	Price per cubic yard.*	Total.
		Cents.	
1	Albert G. Gillespie, Vadalia, La	18½	$740
2	A. P. Martin, Waterproof, La	18½	740
3	Rutherford & Dalgern, Natchez, Miss	19¼	770

* About 4,000 cubic yards

Bids Nos. 1 and 2 are the same. No. 1 having been selected by lot was accepted and contract entered into. Total estimated cost of levee, $740; amount available, $1,000.

United States levee work in the fourth district, Mississippi River, completed during year ending June 30, 1892.

Name of levee.	Miles below Cairo and bank.	Length.	Width of crown.	Slope on land side.	Greatest height.	Least height.	Average height.
Tensas Basin.		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Hardscrabble	639 R	9,840	8	3 and 3 to 1	14.7	9.6	12.2
Kempe, upper section	659 R	3,897	8	3 and 3 to 1	19.2	9.4	14.3
Kempe, middle section	659 R	4,549	8	3 and 3 to 1	14.5	8	11.3
Kempe, lower section	659 R	3,186	8	3 and 3 to 1	12.8	4.3	8.5
Gibsons Landing*	683.5 R	13,888	8 10	3 and 3 to 1	25.6	8.2	16.4
Ferriday Crevasse	693 R	136	8	3 and 3 to 1	16.9	2.1	9.5
Henderson†	712 R	1,814	8	3 and 3 to 1	16.2	12.4	14.3
Right bank below Red River.							
Nina Gap	806.5 R	600	6	3 and 3 to 1	10.3	9.8	10.1
Highland Extension	815.5 R	8,021	8	3 and 3 to 1	15.4	1.9	12.3
Mayflower-Union	853 R	4,743	8	3 and 3 to 1	11.3	0.5	10.1
Fortville	855 R	3,686	8	3 and 3 to 1	12.5	1.1	11
Evergreen‡	857 R	3,400	8	3 and 3 to 1	16	1.6	14½
Dunboine	865 R	783	8	3 and 3 to 1	8.9	0.3	8.1
Left bank below Red River.							
Southwood Extension	875.5 L	9,258	8	3 and 3 to 1	11.6	0.6	9.5
Tessier-Bourgeois	909.5 L	1,959	8	3 and 3 to 1	10.3 9.8	1.1 1.8	9.5 8.9
Southport	955.5 L	1,372	8	3 and 3 to 1	10.4	2.2	9.5

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United States levee work in the fourth district, Mississippi River, etc.—Continued.

Name of levee.	Grade of crown above high water of 1890.	Total. (Net.)	Price per cubic yard.	Amount paid by United States.	When commenced.	When completed.
Tensas Basin.	*Feet.*	*Cubic yards.*	*Cents.*			
Hardscrabble	1.5	193,849.39	22.98	$44,516.58	Oct. 12, 1891	May 26, 1892
Kempe, upper section	2.26	98,157.44	23.79	23,351.65	....do	Feb. 13, 1892
Kempe, middle section	2.26	68,887.67	14.98	10,319.36	Oct. 6, 1891	Feb. 12, 1892
Kempe, lower section	2.26	34,948.72	14.45	5,050.09	Oct. 21, 1891	Feb. 22, 1892
Gibsons Landing*	2.66	338,200.91	19⅜	65,526.43	Dec. 4, 1890	Nov. 25, 1891
Ferriday Crevasse	2.9	3,987.78	18½	737.74	Nov. 4, 1891	Dec. 5, 1891
Henderson†	3	34,125.43	23	7,848.85	Dec. 8, 1890	Sept. 8, 1891
Right bank below Red River.						
Nina Gap	3	8,840.78	20	1,768.16	Feb. 1, 1892	Mar. 1, 1892
Highland Extension	3	199,136.35	15½	30,866.13	Oct. 12, 1891	Jan. 4, 1892
Mayflower-Union	2.5	60,636.65	14⅞	9,019.70	Oct. 17, 1891	Feb. 3, 1892
Fortville	2.5	65,814.01	13.44	8,845.41	Oct. 15, 1891	Jan. 23, 1892
Evergreen‡	3	93,654.73	19	17,794.40	Jan. 1, 1891	Aug. 25, 1891
Dunboine	1.2	7,468.29	15.98	1,193.43	Oct. 14, 1891	Dec. 5, 1891
Left bank below Red River.						
Southwood Extension	3	124,627.93	15½	19,317.32	Oct. 5, 1891	Dec. 29, 1891
Tessier-Bourgeois	2.5	23,524.66	16.98	3,994.49	Oct. 9, 1891	Jan. 7, 1892
Southport	2.5	17,758.97	16	2,841.44	Oct. 6, 1891	Feb. 5, 1892

*208,379.43 cubic yards built this year, at 19⅜ cents, $40,373.51. Extra haul 144,504.10 cubic yards, at 1 cent per 100 feet, $9,470.04.
† All of the levee built during present fiscal year.
‡ 29,435.42 cubic yards built this year, at 19 cents, $5,592.73.

The season was unusually favorable for levee building, owing to a long period of almost uninterrupted good weather in the fall and early winter and the lateness of the spring flood, and all of the work undertaken was completed within contract time except Hardscrabble. The difficulties of this work did not seem to have been fully appreciated by the contractor at first, and a great deal of valuable time and good weather was lost. Finally bad weather, high water, and labor troubles seriously interfered with the progress of the work, but fortunately the old front levee held, although threatened with destruction by the caving of the bank. At this date the levee is completed.

Progress of work on the Southport levee was seriously delayed for want of a sufficient force until finally the rising river threatened to entirely cover the batture from which earth was being obtained for the work. The available earth between the new and the old levee was limited, and there had been so much delay that it was unsafe to use the old levee in building the new one and thus depend entirely on the newly constructed levee to hold the water, as a break at this place would have greatly endangered the city of New Orleans. All efforts to induce the contractor to put on a sufficient force having failed, the quarter boat and force of men were brought down from the willow grounds and put at work on the levee on January 20, under direction of this office. The levee was completed on February 5, and the expense of the extra force deducted from amount paid the contractor, as provided for in the contract.

In addition to construction work a considerable amount of repairs to United States levees in the district was done during the year. This work consisted in clearing levees of trees and brush, restoring the embankment where worn down from crossings or impaired by wave wash or other causes, cutting and filling leaks caused by crayfish holes, and in a few cases raising the grade where it was locally deficient. Repairs of this character were made on the following levees:

Hard Times Dike (633 R).
Hard Times Wilson (631 R).
Evergreen (636 R).
Hardscrabble (639 R).
Kempe (659 R).
Lake Concordia (693 R).
Greens to Fairview (722 R).
Nina (806.5 R).
Highland (815.5 R).
Barroza (823 R).
Ashland to Linwood (878 L).
Grenada to Mount Olive (856.5 L).
Terre Haute to Hope (919.5 L).
Destrahan (939 L).

The work was done partly by a force of men on a quarter boat, with an outfit of tools, which was moved from place to place as the work progressed, and partly by forces of men and teams hired for the purpose, to which the Government did not furnish tools, quarters, or subsistence.

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It is the experience of this office that annual work during low water in the repair and maintenance of the embankments is the most judicious and economical method of applying the bulk of the funds for the protection of levees, and that such yearly expenditures are absolutely essential in order to maintain an effective levee system.

During the months of July, August, and September a continuous line of levels was run over the levees of the Tensas Front from the upper end of the district down to Fairview Landing. Data as to the height of embankments and their general condition was noted at the same time, and a continuous profile has been platted, showing the results of the survey.

Protection of levees.—During the latter part of the winter and early spring all indications pointed to a season of only moderately high water, and many experienced rivermen had estimated on a bank full stage as the highest to be expected. On the contrary, the lower river rose rapidly during the latter part of April, and violent storms became general all over the entire valley of the Mississippi and its tributaries.

As soon as it became evident that a high stage would be reached, preparations were made to supply necessary materials and do such protection work as might become necessary within the limits of the funds available. In these preparations and in subsequent work precedence was given to United States levees. The quarter boat and tools and the force of men that had been employed at the rock quarries near the mouth of Boeuf River were moved to the recently completed Kempe Levee, arriving May 4. A weak place caused by sloughing was repaired and considerable work done on the old Kempe Levee above. On May 20 the force was transferred to Hard Times Landing and repairs begun on the Hard Times Dike across Lake St. Joseph.

Protection work has also been done by hired labor on the Lake Concordia and Henderson levees. The quarter boats *Delta* and *Gamma*, the steamer *Newton*, and at times the tugs *Tilda* and *Laurel* and the launch *Ruby*, besides barges for transporting material, have been employed on protection of levees above Red River.

The tug *Laurel* was chartered on April 27 for duty in protecting levees, principally between Baton Rouge and New Orleans, and she has been used, with the barges as needed, in distributing material.

Assistance has been rendered in maintaining the levees below New Orleans by supplying lumber and sacks which have been transported free of charge by the railroad companies.

According to a recent estimate the assessed valuation of property protected by Mississippi River levees in this district is as follows:

TENSAS BASIN.		
Madison, one-seventh of parish	$293,150	
Tensas, all of parish	1,684,390	
Concordia, all of parish	1,355,948	
Franklin, one-fourth of parish	216,704	
		$3,550,192
RIGHT BANK BELOW RED RIVER.		
West Baton Rouge, all of parish	1,127,185	
Pointe Coupee, all of parish	1,562,545	
Iberville, two-thirds of parish	2,007,045	
Assumption, nine-twentieths of parish	677,870	
Ascension, three-twentieths of parish	304,455	
St. James, one-half of parish	922,721	
St. John, one-fifth of parish	301,693	
Lafourche, one-half of parish	1,177,265	
St. Charles, three-fourths of parish	1,031,569	
Jefferson, one-third of parish	1,103,779	
Plaquemine, one-half of parish	966,870	
		11,182,997
LEFT BANK BELOW RED RIVER.		
Iberville, one-third of parish	223,005	
East Baton Rouge, one-tenth of parish	258,880	
Ascension, fifteen-twentieths of parish	1,725,255	
St. James, one-half of parish	922,721	
St. John, three-fifths of parish	603,386	
St. Charles, one-fourth of parish	343,856	
Jefferson, one-sixth of parish	367,926	
Orleans, nineteen-twentieths of parish	130,000,000	
Plaquemine, one half of parish	966,870	
St. Bernard, one-fourth of parish	208,423	
		135,620,322
Total		150,353,511

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The following table gives a general idea of the present relative condition of the Mississippi River Levees of the District in each of the separate State or subdistricts:

Table showing the general condition of the levees fourth district Mississippi River, June 1, 1892.

Subdistricts in order of general efficiency.	Limits of districts on Mississippi River.	Total number of miles of levee, fourth district.	Number of miles with grade of 2 feet or more above highest river water previous to 1892.	Number of miles with grade of less than 2 feet and more than 1 foot above highest river water previous to 1892.	Number of miles with grade of less than 1 foot above highest river water previous to 1892.	Number of miles of effective United States levees.	Remarks.
1. Orleans levee district.	Comprises all levees on both banks within limits of city of New Orleans, about 13 miles on left bank and 13 miles on right bank.	26	10	16	None.	None.	This is placed first in general efficiency because of its comparatively short length and the labor and material that is immediately available in case of danger.
2. Atchafalaya Basin levee district.	Right bank, from mouth of Red River to Donaldsonville.	129	108	11	10	15	River banks fairly permanent throughout, especially in lower part. Country generally open and banks cleared. Levees exposed to wave wash in lower part of district, and board revetments used for protection below Baton Rouge.*
3. Fifth Louisiana levee district.	Right bank, from upper boundary of State to mouth of Red River.	223	125	46	52	46	In this district the river bank is in many places rapidly caving. Country often heavily wooded. Not much trouble from wave wash.
4. Pontchartrain levee district.	Left bank, from Baton Rouge to upper limit of city of New Orleans.	127	66	31	33	15	The country is all cleared up and open, largely cultivated in sugar and rice. Banks generally permanent. Levees often close to banks and exposed to wave wash. Board revetments largely used.
5. Third levee district.	Right bank, from Donaldsonville to Gulf of Mexico, excepting portion of New Orleans district.	148	65	39	44	None.	Same as above. Orange groves below New Orleans. In lower part of district levees low and generally in bad condition.
6. First levee district.	Left bank of river, from lower boundary of city of New Orleans to Gulf of Mexico.	70	22	24	24	None.	Levees generally low and very inefficient.

*In general the height of the embankments and their distance from the bank lines increase from the lower to the upper parts of the district. The permanence of the bank line and the danger from wave wash increase from the upper to the lower part of the district. Below Baton Rouge the facilities for transporting materials by land and river and the supply of local labor are very good.

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The following crevasses occurred during the high water of 1892:

Name, bank, and miles below Cairo.	Date of break.	Date closed.	Remarks.
Leblanc (942 R.)	Apr. 25		Bayou Lafourche.
Napoleonville (904 R.)	Apr. 26		Do.
Point a la Hache (1,010.5 L.)	May 14	May 14	Mississippi River.
Villere (969 L.)	May 3	May 4	Do.
Mon Secour (995 L.)	May 11	May 11	Do.
Harlem (1,000 L.)	May 12	May 20	Do.
Anchor (928 L.)	May 16		Do.
Happy Point (922 R.)	May 18	May 28	Do.
Tessier (907 L.)	May 22	June 5	Do.
Belair (995 L.)	May 24	May 28	Do.
Cedar Grove (983 L.)	May 24	May 28	Do.
Harlem (1,000 L.)	May 25		Do.
Story (972 L.)	May 28	May 30	Do.
New Hope (897 R.)	June 1		Do.
Belle Chasse (987.5 R.)	June 3	June 15	Do.
Ascension (882 R.)	June 7		Do.
Villere (970 L.)	June 7		Do.
Story (972 L.)	June 11		Do.
Merritt (975 L.)	June 13		Do.
Prospect (935 L.)	June 13		Do.
Belmont (908 L.)	June 12		Do.
Avondale (953 R.)	June 13	June 16	Do.
Hermitage (887 L.)	June 21		Do.
Delogny (907 R.)	June 23		Do.
Bohemia (1,014 L.)	June 27		Do.

LEVEES, TENSAS BASIN.

Money statement.

July 1, 1891, balance unexpended		$117,532.16
July 18, 1891, transferred from protection of levees, Tensas Basin		38,475.00
July 18, 1891, pro rata allotment from Lake Providence Reach allotment (of $75,000)		11,542.50
September 16, 1891, transferred by Capt. Townsend, third district, being pro rata of $75,000 allotment from Lake Providence Reach		1,334.75
May 4, 1892, transferred from protection of levees, Tensas Basin		3,000.00
Total		171,884.41
May 31, 1892, expended during fiscal year to date		160,212.39
June 1, 1892, balance unexpended		11,672.02
In hands		11,672.02
Less amount covered by existing contract	$11,522.31	
Less estimated liabilities	100.00	
		11,622.31
Available		49.71
Amount that can be profitably expended during fiscal year ending June 30, 1894		250,000.00

PROTECTION OF LEVEES, TENSAS BASIN.

Money statement.

July 1, 1891, balance unexpended		$47,989.02
July 18, 1891, 5 per cent of pro rata allotment from Lake Providence Reach allotment (of $75,000)		607.50
September 16, 1892, transferred by Capt. Townsend, third district, being 5 per cent of pro rata allotment of $75,000 from Lake Providence Reach.		70.25
April 30, 1892, transferred from general service allotment		5,000.00
May 31, 1892, transferred from general service allotment		5,000.00
Total		58,666.77
July 18, 1891, transferred to levees, Tensas Basin	$38,475.00	
May 4, 1892, transferred to levees, Tensas Basin	3,000.00	
		41,475.00
Balance		17,191.77
May 31, 1892, expended during fiscal year to date		9,088.60
June 1, 1892, balance unexpended		8,103.17

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In Treasury, United States	$5,000.00
In hands	3,103.17
	8,103.17
Less outstanding liabilities (estimated)	1,200.00
June 1, 1892, balance available	6,903.17
Amount that can be profitably expended during fiscal year ending June 30, 1894	25,000

LEVEES, RIGHT BANK, BELOW RED RIVER.

Money statement.

July 1, 1891, balance unexpended	16,510.15
July 18, 1892, transferred from protection of levees, right bank, below Red River	41,562.50
July 18, 1891, pro rata allotment from Lake Providence Reach allotment (of $75,000)	12,468.75
September 16, 1891, transferred by Capt. Townsend, third district, being pro rata of $75,000 allotment from Lake Providence Reach	1,441.15
Total	71,982.55
May 31, 1892, expended during fiscal year to date	69,920.61
June 1, 1892, balance unexpended	2,061.94
In hands	2,061.94
Amount that can be profitably expended during fiscal year ending June 30, 1894	250,000

PROTECTION OF LEVEES, RIGHT BANK, BELOW RED RIVER.

Money statement.

July 1, 1891, balance unexpended	48,071.25
July 18, 1891, 5 per cent of pro rata allotment from Lake Providence allotment (of $75,000)	656.25
September 16, 1891, transferred by Capt. Townsend, third district, being 5 per cent of pro rata allotment of $75,000 from Lake Providence Reach.	75.85
May 31, 1892, transferred from general service allotment	3,000.00
Total	51,803.35
July 18, 1891, transferred to levees, right bank, below Red River	41,562.50
Balance	10,240.85
May 31, 1892, expended during fiscal year to date	1,363.47
June 1, 1892, balance unexpended	8,877.38
In Treasury, United States	3,000.00
In hands	5,877.38
	8,877.38
Less outstanding liabilities (estimated)	3,500.00
June 1, 1892, balance available	5,377.38
Amount that can be profitably expended during fiscal year ending June 30, 1894	25,000.00

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LEVEES, LEFT BANK, BELOW RED RIVER.

July 1, 1891, balance unexpended	$5,717.14
July 18, 1891, transferred from protection of levees, left bank, below Red River	21,850.00
July 18, 1891, pro rata allotment from Lake Providence Reach allotment (of $75,000)	6,750.70
September 16, 1891, transferred by Capt. Townsend, Third district, being pro rata of $75,000 allotment from Lake Providence Reach	780.90
Total	35,098.74
May 31, 1892, expended during fiscal year to date	34,146.71
June 1, 1892, balance unexpended	952.03
In hands	952.03
Amount that can profitably be expended during fiscal year ending June 30, 1894	250,000.00

PROTECTION OF LEVEES, LEFT BANK, BELOW RED RIVER.

Money statement.

July 1, 1891, balance unexpended	$24,689.06
July 18, 1891, 5 per cent of pro rata allotment from Lake Providence allotment (of $75,000)	355.30
September 16, 1891, transferred by Capt. Townsend, Third district, being 5 per cent of pro rata allotment of $75,000 from Lake Providence Reach	41.10
May 31, 1892, transferred from general service allotment	3,000.00
Total	28,085.46
July 18, 1891, transferred to levees, left bank, below Red River	21,850.00
Balance	6,235.46
May 31, 1892, expended during fiscal year to date	1,788.00
June 1, 1892, balance unexpended	4,447.46
In Treasury United States	3,000.00
In hands	1,447.46
	4,447.46
Less outstanding liabilities (estimated)	2,600.00
June 1, 1892, balance available	1,847.46
Amount that can be profitably expended during fiscal year ending June 30, 1894	25,000.00

All levee work above the mouth of Red River has been under the immediate charge of Assistant Engineer H. S. Douglas, and that below the mouth of Red River under the immediate charge of Assistant Engineer W. J. Hardee. They report as follows:

NATCHEZ, MISS., *May 31, 1892.*

SIR: I have the honor to submit the following report on the construction and repair of levees, Tensas Basin, Fourth district, from June 1, 1891, to May 31, 1892.

At date of last report, May 31, 1891, work was in progress at Gibson Landing Levee (683.5 R.). The Henderson Levee (712 R.) was unfinished, the contractors having failed to complete it before the high water of 1891. There was a crevasse in Lake Concordia Levee (693 R.) which had been temporarily closed with a sack dike.

All work of construction being done by contract, no plant, strictly speaking, belonged to this work.

At Gibson Landing Levee 5,500 feet of embankment had been completed out of a total of 13,888 feet.

On September 8, 1891, under allotments made by the Mississippi River Commission, the following levees were advertised, awards made, and contracts entered into:

	Cubic yards.
Hardscrabble (639 R.), about	104,000
Kempe, upper section (659 R.), about	98,500
Kempe, middle section (659 R.), about	68,000
Kempe, lower section (659 R.), about	33,700

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On October 14, 1891, proposals were asked by circular letter for a levee to close the gap in Lake Concordia Levee, known as the Ferriday Crevasse (693 R.). Award was made and agreement entered into with Albert H. Gillespie for its construction.

The following is a summary of work done:

Hardscrabble Levee (639 R.).—Grade, 1.5 feet above high water of 1890; crown, 8 feet; slopes, 3 and 3 to 1; contents, 193,849.39 cubic yards. Several lines had been previously surveyed at this locality, but prior to the opening of bids the funds allotted were not considered sufficient to build even the shortest of these lines. On September 15 a survey was made to locate, if possible, a safe line that would contain not more than the advertised amount, 104,000 cubic yards. The survey indicated that it would be impossible to build a levee that would contain this yardage and be permanent for any reasonable length of time. Fortunately the prices bid on levees were so much lower than estimated that after the opening of bids it was found possible, by slightly reducing the grade, to build the shortest of the lines that seemed to be reasonably permanent.

On October 12, 1891, the contractors commenced operations with a small force. They evidently did not realize the difficult task which they had undertaken and, although repeatedly urged to increase their force and push the work to completion, they allowed the favorable weather to pass without accomplishing much. The result was that the work dragged along into the rainy season and when the contract time for completion arrived the levee was only about two-thirds finished. Fortunately the old front levee had not caved into the river. The time of completion was extended until April 15, 1892. Further extensions of time, owing to bad weather and high water, were granted the contractors as follows: Until May 1, May 15, and June 1. Finally by extraordinary exertions the levee was completed May 26, 1892.

Kempe Upper Section Levee (659 R.).—Grade, 2.26 feet above high water of 1890; crown, 8 feet; slopes, 3 and 3 to 1. Practically the Upper, Middle, and Lower sections of Kempe Levee are one continuous piece of embankment. It was separated and let in three sections so as to insure its completion before high water and because there was sufficient difference in the character of the work to justify the belief that lower prices in the aggregate would be bid under this method than if the work had been let as a whole. The upper section contained 98,157.44 cubic yards, and the length of the embankment is 3,897 feet.

Work was commenced October 12, 1891, and pushed with reasonable energy to completion on February 13, 1892. A portion of the embankment crossing a slough would not stand on the required slopes and has slipped and flattened out so that it is below the established grade. It is, however, sufficiently high to restrain an ordinary high water, and there being no danger it was decided to leave this portion of the bank to consolidate and come to a state of rest before doing any more work on it.

Kempe Middle Section Levee (659 R.).—Grade, 2.26 feet above high water of 1890; crown, 8 feet; slopes, 3 and 3 to 1; length of embankment, 4,549 feet; contents, 68,887.67 cubic yards. Work was commenced October 6, 1691, and the levee was completed February 12, 1892. No special feature occurred in the course of construction.

Kempe Lower Section Levee (659 R.).—Grade, slopes, and crown the same as the upper and middle sections of Kempe Levee. Work was commenced October 21, 1891, and the levee was completed February 22, 1892, without any incident of note.

Gibson Landing Levee (683.5 R.).—Work was in progress at date of last report. Construction was pushed rapidly and the levee was completed November 25, 1891. For a distance of 1,700 feet this levee crosses the bed of Lake St. John, and it was anticipated that unusual difficulty would be experienced in construction. It was believed that the yielding character of the soil forming the lake bed would not sustain the weight of the very heavy embankment required. Sinking of levee did take place, but it was confined principally to a length of about 500 feet in the center of the lake. Similar cases in the past had been a prolific cause of trouble with contractors, in some instances leading to litigation. Warned by past experiences, borrow pits had been carefully laid off and cross-sectioned and the earth for this portion of the embankment was taken from these pits. On completion of the levee a careful resurvey determined the amount of earth taken from the pits and also the extra haul. Having ample data a fair and satisfactory settlement was made with the contractor. In the construction of the "lake" portion of the levee unusual enterprise and ingenuity was shown. The earth was hauled in wagons which were loaded rapidly and economically with a patent machine based on the general plan of an elevator dredge. A very satisfactory embankment was built by this method, although the sinking necessitated a modification of the side slopes. Since completion no further sinking of consequence has taken place.

Ferriday Crevasse Levee (693 R.).—This was a small affair. The break occurred on a falling river and was closed with a sack dike. No scour of consequence occurred

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and the crevasse was closed on the center line of the original levee. Work was commenced on November 4, 1891, and the levee was completed December 5, 1891.

Henderson Levee (*713 R.*).—The high water of 1891 had again flowed through this gap, as the contractors had failed to complete the levee before flood time. The overflow had washed away such portions of the new levee as were in place and slightly enlarged the crevasse of 1890. The local topography having been considerably changed by the flood a resurvey for a line of levee to close the gap was necessary. The resurvey was made during June, 1891. The levee was completed without any unusual incidents on September 8, 1891.

REPAIR OF LEVEES, TENSAS BASIN.

An allotment of $11,000 was made for the repair of the United States levees on Tensas Basin. A quarter boat was borrowed from the Red and Atchafalaya works and an organized force, equipped with the proper tools, placed on board. The force was under the immediate direction of an inspector, who was thoroughly familiar with the entire line of levees. The average force employed consisted of about 50 men, including such employés as were necessary for supervision, subsistence, etc. Operations were commenced October 21, 1891, at the upper end of the old Hardscrabble Levee, *i. e.*, that portion not thrown out by the construction of the new line. Some work was also done on the lower end of Evergreen Levee. Upon the completion of this work the force was transferred to the lower end of Hardscrabble, where extensive repairs were made. When this work had been completed the quarter boat was dropped down to Upper or Old Kempe Levee, which was put in good condition, all weak points developed by the high water of 1890 and 1891 being thoroughly repaired and strengthened. From Kempe the repair force was transferred to the United States Green's to Fairview Lèvee, which includes as a loop Deer Park Levee. Here the most extensive repair work was done. A considerable portion of the levee had grown up with trees, saplings, briers, and weeds, and for some distance the levee was too low for a flood equal to 1890. A narrow ridge had been thrown up hastily on the crown to resist the flood of that year. This ridge was reinforced and the levee was thoroughly cleared, all trees and saplings being grubbed out by the roots. This work was completed January 13, 1892, and the quarter boat moved to Hard Times Levee, from which point the balance of Evergreen and all of Hard Times Levee was thoroughly repaired and cleared of trees, saplings, briers, and weeds. From Hard Times the repair force was moved to Lake Concordia, where a large amount of repair work was done. The repairs to this levee were not entirely completed, as before completion available funds were exhausted, and on March 14, 1892, the repair force was disbanded. The quarter boat was taken to laying-up quarters in New Orleans Harbor.

During the greater part of this time repair work had been in progress on Lake Concordia by hired labor, local labor being employed and furnished with the necessary tools. This force quartered and subsisted themselves.

An informal agreement was made for the clearing and repair of the United States Hard Times-Wilson Levee, and under this agreement a great deal of work was done. The levee was cleared of saplings, briers, weeds, etc., for a distance of 9,000 feet, and all sand boils and leaks through the levee for a distance of 627 feet repaired. Considerable work in the way of repairing rain and wave wash yet remains to be done, but the lack of funds necessitated the suspension of work.

It was hoped to acquire some valuable data as to the cost of repair work on levees. The following will give a general idea, so far as the force operated from the quarter boat is concerned:

Total length of levee repaired, in feet	
Total cost, including subsistence and supervision	
Total repairs to plants, care of plant, etc	
Cost per 100 feet of levee repaired	
Cost of subsistence raw per man per day	
Cost of subsistence served per man per day	

SUMMARY.

On Tensas Basin, fourth district, the United States has now about 51.3 miles of effective levee, and I report its present condition as follows:

Bedford Levee (*606 R.*).—Length, 3,030 feet. Is generally in good condition. It is somewhat gullied by rain wash, and is partially grown up with weeds.

Point Pleasant Levee (*624 R.*).—A large portion of this levee, built by the United States in 1882, 1883, 1884, and 1885, has been thrown out by the construction of a new line by the local authorities. Of the work of the United States there now remains

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an effective length of about 2,000 feet, which is not in very good condition, it having been worn down by foot and bridle paths.

Hard Times-Wilson Levee (*631 R.*).—The length of effective levee here is now 39,215 feet, a considerable portion having been thrown out by the construction by the local authorities of a new levee at Buckridge or Point Pleasant. The levee has been cleared of brush, weeds, etc., over the entire length. A stretch of 10,000 feet is in bad repair, being badly washed by rain and waves. This portion is in such condition that it would scarcely stand another flood equal to 1890. The balance of the line has been thoroughly repaired and is in good condition.

Hard Times Levee (*633 R.*).—Length, 4,000 feet. This short piece of levee is one of the most important in the district, as it is the dike at the foot of Lake St. Joseph. A break here would be most disastrous, as it would in all probability cause an entire abandonment of the existing levee lines in the vicinity, which are all United States levees. It has been repaired and again raised at the sinking portion in the bed of Lake St. Joseph.

Evergreen Levee (*637 R.*).—Length, 10,000 feet. This levee is now in fairly good condition, having been cleared of a dense growth of trees, briars, weeds, etc., and raised at such places as it was notoriously low in grade. It is a low-grade levee, and for this reason only may give trouble.

Hardscrabble Levee (*639 R.*).—Length, 22,000 feet. Under this head a long line is included: Upper Hardscrabble, or that portion comprised between the end of Evergreen and the new Hardscrabble Levee of 1891-'92; the new Hardscrabble Levee, built to close a prospective gap in the front line; and the Lower Hardscrabble, extending from the lower end of the new levee to the Bondurant (State) Levee. At Upper Hardscrabble the levee was cleared of a rank growth of saplings, briars, weeds, etc., and extensively raised on the crown, where, but for a narrow ridge of earth and sacks hastily thrown up at the height of the flood of 1890, the water would have flowed over the top. The same character of work was done on Lower Hardscrabble. The new Hardscrabble Levee of 1891-'92 has a stronger section and a higher grade than the old one which it adjoins. It has just been completed. Owing to the continued caving of the river bank in front there are strong probabilities that the lower wing of the new levee will soon have to be abandoned and the curtain extended much farther downstream.

Bondurant Levee (*644 R.*).—Length, about 2,000 feet. This is all the effective length of levee left built by the United States in 1882, 1883, 1884, and 1885, the balance of the line having caved into the river or having been thrown out by the construction of new lines by the local authorities. This short piece is in fairly good condition.

Kempe Levee (*657 R.*).—Length, 27,700 feet. Under this head will be included Upper or old Kempe (656 R.) Levee, completed in 1889, and that portion, built in 1891-'92, called upper, middle, and lower sections of Kempe (659 R.). Several levees have been built by the United States, and the above is the length of the present effective line. It is a long levee of generally very unusual height, and its present condition is fairly good. The upper or old levee is in good condition, but the lower portion has been rain-washed, and the sod, being set at an unfavorable time, has been killed by frost in places. In addition, a short portion of the levee has sloughed and is in bad condition.

Gibson Landing Levee (*683.5 R.*).—Length, 13,883 feet. This levee was completed on December 5, 1891. The line crosses the bed of Lake St. John, and for a distance of 1,500 feet is of unusual height. It is a high-grade levee and generally in fair condition. A considerable portion of the line is badly rain-washed, and the sod has not grown, owing to frost and drought at the time it was set.

Lake Concordia (*693 R.*).—Length, about 100,000 feet. This long line of levee was originally built by the United States in 1882-'83. Crevasses occurred in 1884, and short lines of new levee to close these gaps were built in 1884-'85. In 1890 an extensive break occurred, and a heavy line of levee 3,030 feet long was built to close the break. In 1891 another break occurred, but it was a small one, and was closed on the line of the original levee in 1892. The Lake Concordia Levee was extensively repaired this year, but the repairs were not completed, owing to lack of funds.

Arnauldia Levee (*703 R.*).—Length, 578 feet. This is a short piece of light levee, built to close a crevasse of 1890. It is of little importance and is in fair condition.

Greens to Fairview and Deer Park (*724 R.*).—Length, about 55,000 feet. This long line of levee was built by the United States in 1882, 1883, 1884, 1887, and 1891. It is a remarkably good levee and has given no trouble, except from lack of height. The high water of 1890 overtopped the levee in several places. It has been extensively repaired. The dense growth of trees, briers, and weeds in the Glascock Swamp portion of the levee has been cleared off, the trees being grubbed out by the roots. The light ridge thrown up during the flood of 1890 has been reinforced and the line is generally in good condition.

Deer Park (*10,288 feet in length*).—This is a part of the United States Greens to Fairview Levee. The cause of the building of this embankment was the rapid caving of

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the river bank, which breached the original line and necessitated the building of what is termed a run-around on an extensive scale. The first Deer Park Levee was built in 1887. The continual caving of the bank necessitated the building of another levee in 1890-'91. This embankment still exists, but the lower wing is again threatened by the caving of the river bank.

In conclusion I would state that I believe that the improvement in the general condition of levees, Tensas Basin, Fourth district has continued and that they are now in better condition than at any time since 1882.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Lieut. JOHN MILLIS,
Corps of Engineers, U. S. A.

BATON ROUGE, LA., *May 31, 1892.*

SIR: I have the honor to submit the following report upon the works of which I have had local charge during the year ending May 31, 1892:

LEVEES, RIGHT BANK, BELOW RED RIVER—CONSTRUCTION.

On June 1, 1891, the only work in progress was at Nina, La. (806.5 R.), and Evergreen, La. (857 R.), at which places the levees commenced during December, 1890, and under contract to be completed by March 1, 1891, were not finished by that time and for reasons set forth in my last annual report extensions were granted, and when that report was submitted work was in progress on those levees.

Nina Levee.—With the exception of the 600 feet left open for the removal of the Nina Plantation buildings, for which a supplemental contract was made with Contractor S. L. James, jr., all of this levee was completed but 200 feet, which portion of the work was a dike across a deep bayou.

The greatest net fill in this bayou was 37 feet. When the survey was made for computation of quantities the water in the bayou was at a low elevation. The greatest depth was 12 feet, with from 3 to 5 feet of soft mud on the bottom. This portion of the work was built with a 6-foot crown, riverside slope of 3½ to 1 and a land slope of 4 to 1.

To insure removal of all foreign and injurious substances from within the base of the levee, and to provide against sloughing and consequent loss of material almost sure to follow the dumping of the light loam constituting the construction material in so much water, the contractor built a wing dam at the outer edge of either base of the levee, and by means of an ordinary barge pump removed the water from within the inclosure. Five large sections of cypress trees were removed and a large cypress stump destroyed and removed by blasting with dynamite, when embankment construction was commenced and carried on to a successful completion without experiencing either sloughing or apparent sinking. The work was completed and accepted on June 14, 1891.

Evergreen Levee.—On June 1, 1891, there were 2,300 feet of this levee, embracing 33,271 yards, yet to be completed. On March 1, 1891, the time prescribed for completion, the work was but slightly advanced and for reasons stated in last annual report an extension of time to July 31, 1891, was granted. During June and July the water in the river was at a low elevation, and authority was granted to use the old levee in the construction of the new. Relieved of the many obstacles previously encountered, the work proceeded rapidly and was completed and accepted on July 21, 1891.

SURVEYS AND INSPECTIONS.

On July 16 and 17, 1891, an inspection was made of all completed United States levees on this bank. An estimate was submitted giving the approximate amount necessary to restore rain and wave washes, remove all objectionable vegetation and resod, cut out crayfish holes and other leaks, etc. The aggregate amount was $275. It was recommended that in addition to the described repair work, a berme or base ditch be cut in the rear of each levee to provide for the prompt removal of seep water, a dangerous agency during flood periods, for where such water remains unremoved it saturates the embankment, provoking sloughing as well as general instability. The estimated aggregate cost of such ditching was submitted as $5,958.

Between August 23 and August 26, 1891, surveys were made to determine the location and approximate cost of levee lines at Mayflower-Union (853 R.) and Dunboine (865 R.). A survey had previously been made for the Highland Levee (814.5 R.) extension.

The board of district officers on building and repairing levees, accompanied by the

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chief of the Louisiana State board of engineers, passed through the district between August 22 and 24, 1891, on the U. S. S. *Titan*, making personal examination of the localities where it was proposed to apply the allotted funds.

While in session at New Orleans the board decided upon the construction of the Highland Extension, Mayflower-Union, and Dunboine levees. After providing for those works and the repair and contingent fund, a balance of $5,500 remained, which was allotted to a levee at Eliza (844 R.).

On September 23, 1891, awards were made for all the levees but Eliza, which was recalled prior to the opening of proposals. This action was the result of a survey made at the locality, which showed no breach in the existing levee. Further, that the position of that levee relative to the bank line justified the conclusion that in the event of a breach so much of the levee would be lost at one time as to render the allotment of $5,500 inadequate for the construction of such a line as would then be necessary, and the money could not be judiciously applied, except in conjunction with the local authorities by building part of a long line. This was considered inadvisable and the State authorities were notified that the United States would do no work at the locality.

During the latter part of August, 1891, a large cave occurred at the lower end of the town of Plaquemine, destroying about 600 feet of the levee. Authority was requested and granted to apply the money previously recommended for expenditure at Eliza to the construction of a new levee at this point. The work was advertised and awarded as the Fortville Levee (855 R.).

CONSTRUCTION.

Nina Levee.—As late as last January 22, 1892, the contractor had failed to put in an appearance to execute his supplemental agreement. On January 23 the contract was annulled and the levee completed by James R Marlow in open market for 20 cents per cubic yard.

Work was commenced on February 1, 1892, and completed March 1, 1892. It is 600 feet long, averages 10.1 feet high, has a crown of 6 feet, side slopes of 3 and 3 to 1, and contains 8,840.78 cubic yards. The largest force employed on one day was 28 men and 36 mules.

Highland Extension.—This levee was awarded to John Scott & Son on September 23, 1891, for 15¼ cents per cubic yard. It is 8,021 feet long, averages 12.3 feet high, has an 8-foot crown, side slopes of 3 and 3 to 1, and contains 199,136.35 cubic yards.

The levee constructed last year by the United States was not then joined at its upper end to the old levee, owing to the lack of funds and the fact of the old levee remaining intact. The old levee is now partly breached, and to provide for replacement of that portion of it dangerously near the bank at points above the terminus of last year's work the extension was made.

The largest force employed on one day was 148 men and 204 mules. Operations were commenced on October 10, and the work was systematically and vigorously prosecuted, resulting in its completion and acceptance as early as January 5, 1892.

Mayflower-Union.—This levee as originally designed was 3,420 feet long and estimated to contain 43,495 cubic yards. It was awarded September 23 to Noble W. Irish for 14¾ cents per cubic yard. Work was started on October 15 with a small force of men and mules, shortly afterwards being increased. The largest force employed on one day was 44 men and 62 mules. About October 1, 1891, a large cave occurred, the bank line receding to within 30 feet of a salient angle of the old levee, a short distance below the point selected for the terminus of the new line. This necessitated extending the new line, which was done.

The levee as built consists of two sections of new levee aggregating 3,882 feet in length, averaging 10.1 feet high, with an 8-foot crown, and side slopes of 3 and 3 to 1. Between the sections of the new levee there existed a levee sufficiently removed from the river bank to be considered reasonably permanent, and this levee was enlarged to conform to the cross-section of the new work. The yardage of the enlarged and two new sections aggregates 60,636.65.

Lack of experience in executing such work, in the beginning, and bad weather that prevailed near its conclusion extended completion several weeks beyond the time at which it should have been accomplished with the force employed. The levee was completed and accepted on February 3, 1892.

Fortville Levee.—This work was awarded on October 7, 1891, to the Andrews Brothers Construction Company for 13.44 cents per cubic yard. It is 3,686 feet long, averages 11 feet high, has an 8-foot crown, side slopes of 3 and 3 to 1, and contains 65,814.01 cubic yards.

Work was commenced on October 16 and continued with but small loss of time until January 23, 1892, when it was completed and accepted. Rapid progress was made during the first six weeks the force was employed. Progress was retarded

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near the completion of the work by reason of rains and character of dirt handled. The largest force employed on one day was 49 men and 66 mules.

Dunboine Levee.—This is a small affair, and was built in anticipation of a breach in the existing levee at a point where a horseshoe-shaped cave had occurred, putting the bank line within 20 feet of the riverside toe of the levee. The bank for about half a mile on either side of the cave is not a rapid caving bank, but more properly a washing bank. For this reason the local authorities in proceeding with their work of repair and enlargement of levees omitted this mile or more of levee, all of which is close to the bank, intending it to remain until a new levee becomes necessary. The levee built by the United States was therefore considered of a temporary nature, and was built by the United States to the grade of the existing levee. It is 783 feet long, averages 8.1 feet high, has an 8-foot crown, side slopes 3 and 3 to 1, and contains 7,468.29 cubic yards. It was awarded to Gibson & Deaton on September 23, for 15.98 cents per cubic yard.

Work was commenced on October 14; good weather prevailed, progress was rapid, and it was completed and accepted on November 30. The largest force engaged on one day was 12 men and 16 mules.

REPAIRS.

Owing to the nature of the repair work to be done, it was deemed advisable to employ required force in open market, which was done.

Nina Levee (806. 5 R.).—Portion of this levee had been badly washed by rains, particularly the dike. Almost the entire levee was thickly grown over with weeds, which had not permitted sod to grow. The levee was thoroughly repaired, at a cost of $298. 62.

Highland Levee (815.5 R.).—Scattering weeds had grown on this levee and in places the original sod had failed to grow. The slopes and crown were badly washed in places, particularly the riverside slope of the dike and the banquette in the rear of same. Necessary repairs were made, at a cost of $228.25.

Barroza Levee (823 R.).—Very few weeds had grown on this levee, but it was badly rain-washed and very little of the original sod had grown. The levee is a large one, and bad weather was experienced, while the force was at work, which, together with the inaccessability of material for repairs, increased the cost. Necessary work was done, at an expense of $1,151.74.

The excess of cost over the estimate for the repair work is accounted for by the damage caused by washing of the levees between the time estimate was made and the work accomplished.

SUPERVISION.

One assistant engineer in general charge and an inspector stationed at each levee was the force employed directly by the United States for the necessary care and supervision of the levees while building. The United States launch *Alaska*, with crew consisting of 1 master, 1 engineer, and 1 fireman, was detailed for duty in connection with levee work on this bank and was of great value in expediting the movements of the assistant engineer. A master laborer was stationed with the repair force to provide for the proper execution of that work and to keep and render reports of the force employed.

LEVEES, LEFT BANK, BELOW RED RIVER—SURVEYS AND INSPECTIONS.

Between July 17 and July 22 an inspection was made of all United States levees and an estimate submitted aggregating $6,400 as necessary to properly repair them, and $4,948 to excavate a berme or base ditch in rear of each.

Between August 20 and September 23, 1891, surveys were made to determine the location and cost of levee lines at Southwood Extension (876.5 L.), Tessier-Bourgeois (909.5 L.), and Southport (955.5 L.).

On August 23 and 24, 1891, the Board of district officers on building and repairs of levees passed through the district on the U. S. S. *Titan*, making personal examination of the above and other localities, looking to the application of the available levee allotment.

CONSTRUCTION.

On June 1, 1891, no work was in progress.

Southwood Extension Levee.—This work was awarded to Keogh, Moore & Co., on September 23, for 15½ cents per cubic yard. It was built in anticipation of a breach in the existing levee by caving banks. The levee is 9,258 feet long, averages 9½ feet

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high, has an 8-foot crown, side slopes of 3 and 3 to 1, and contains 124,627.93 cubic yards. Work was commenced on October 5, and good weather prevailed. The work was ably and vigorously prosecuted, and completed December 30. The largest force on one day was 114 men and 158 mules.

Tessier-Bourgeois Levee.—This work was awarded to Gibson & Deaton, on September 23, for 16.98 cents per cubic yard.

The work consists of two sections of new levee about one-half mile apart, both being built in anticipation of a breach in the old levees. The upper (Tessier) section is 1,016 feet long, averages 9¼ feet high, and contains 12,742.21 cubic yards.

The lower (Bourgeois) section is 943 feet long, averages 8.9 feet high, and contains 10,782.45 cubic yards. Both sections have an 8-foot crown and side slopes of 3 and 3 to 1.

Work was commenced on October 9 and completed January 2, 1892.

The largest force engaged on one day was 19 men and 30 mules.

Southport Levee.—This work was built to provide for a threatened breach in the existing levee. It was awarded to Louis Lesassier, on September 23, for 16 cents per cubic yard, is 1,372 feet long, averages 9.5 feet high, has an 8-foot crown, side slopes of 3 and 3 to 1, and contains 17,758.97 cubic yards.

Work was commenced on October 5 with a small force. The space between the new and old levees is limited, and would not afford sufficient material for the construction of the new line. It was considered inadvisable to allow the old levee to be disturbed, and the major portion of the dirt for the new line had to be obtained from the batture on the river side of the old levee. The work was badly handled and but a small force employed. The contractor was repeatedly notified of the unsatisfactory progress of the work. By January 15, 1892, so much of the contract time had elapsed and the river was rising, gradually covering and limiting the batture, that something more substantial than notifications to the contractor had to be done, so to insure the completion of the work in advance of high water, a force was put upon the work by the United States and charged to the contractor in the final settlement. This force commenced work on January 20 and was maintained until February 4, when the levee was completed and accepted.

The largest force employed on one day was 185 men and 169 wheelbarrows, which included the force operated by the United States.

REPAIRS.

A similar force to that employed on repairs on right bank was operated on this bank. Work was confined to the levees in the worst condition and most requiring repair.

Ashland to Linwood Levee (878 L).—During high water of 1891 many leaks existed under the base of this levee. To destroy them a deep trench was cut along the front edge of the slope of the levee and afterwards refilled and tamped with clay. Wave and rain washes were restored, weeds removed, and the levee resodded where necessary at a total cost of $1,081.87.

Grenada to Mount Olive Levee (856.5 L).—Wave and rain washes were restored, weeds removed, and the levee resodded where necessary; in addition to which the wooden revetment was overhauled and made secure, all at a cost of $652.

Terre Haute to Hope Levee (919.5 L).—The same work was performed here as on Grenada to Mount Olive Levee, at a cost of $338.50.

Destrahan Levee (939 L).—Wave and rain washes were restored, weeds removed, and the levee resodded, at a cost of $326.25.

SUPERVISION.

The system of supervision was the same as used on levees, right bank, the United States launch *Alaska* also rendering service.

Very respectfully, your obedient servant,

W. J. HARDEE,
Assistant Engineer.

Lieut. JOHN MILLIS,
Corps of Engineers, U. S. A.

SURVEYS, GAUGES, AND OBSERVATIONS.

Besides the surveys made in connection with works for which there were specific allotments, the only surveys or observations undertaken during the year related to discharge measurements.

The low-water discharge was taken in the Mississippi at Red River Landing, in the Atchafalaya near Simmsport, and in the Red River Dam.

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High-water discharges were measured in the Mississippi at Natchez, Red River Landing, and Carrollton, and in the Atchafalaya at Simmsport.

New bulletin boards were erected at the following gauges: College Point, Barbres Landing, Plaquemine, Bayou Sara, and St. Joseph.

The gauge at Simmsport was discontinued, by approval of the Commission, on May 15.

By direction of the Commission the care and maintenance of the following-named gauges will be transferred to the secretary of the Commission on June 1: St. Joseph, Bayou Sara, Plaquemine, College Point, and Fort Jackson.

The following table shows the highest and lowest readings of the gauges of the district during the year and the highest and lowest readings with the date that were previously recorded at each gauge:

Highest gauge readings.

Gauges.	1889-'90.		1890-'91.		1891-'92.	
	Date.	Reading.	Date.	Reading.	Date.	Reading.
Mississippi River:	1890.		1891.		1892.	
Vicksburg, Miss	Apr. 25	49.1	Apr. 2	48.1	May 10	48.4
St. Joseph, La	Apr. 23	45.15	Apr. 13	43.70	June 4	44.55
Natchez, Miss	Apr. 23	48.60	Apr. 11	46.50		
Red River Landing, La	Apr. 23	48.80	Apr. 27	45.48		
Red River:						
Barbres Landing, La	Apr. 23	49.70	Apr. 25	45.65		
Sugar House, La			Apr. 30	45.99		
Atchafalaya River:						
Melville, La	Apr. 28	35.4	Apr. 19	33.7		
Simmsport, La	Apr. 22	45.50	Apr. 26	43.32		
Mississippi River:						
Bayou Sara, La	Apr. 21	41.2	Apr. 29	38.8		
Baton Rouge, La	Apr. 21	36.75	May 3	35.55		
Plaquemine, La	Apr. 22	31.9	Apr. 29	31.0		
College Point, La	Mar. 16	23.90	Mar. 16	23.40		
Carrollton, La	Mar. 17	16.10	Mar. 16	16.0		
New Orleans, La	Mar. 21	16.7	Mar. 17	16.4		
Fort Jackson, La			Mar. 16	6.15		

Lowest gauge readings.

Gauges.	1889-'90.		1890-'91.		1891-'92.	
	Date.	Reading.	Date.	Reading.	Date.	Reading.
Mississippi River:	1889.		1890.		1891.	
Vicksburg, Miss	Nov. 8	0.2	Aug. 18	9.0	Oct. 22	−2.1
St. Joseph, La	Oct. 31	−3.95	Aug. 20	5.2	Nov. 15	−4.0
Natchez, Miss	Nov. 4	2.7	Aug. 21	11.60	Nov. 16	4.05
Red River Landing, La	Nov. 4	2.40	Aug. 23	8.8	Nov. 12	0.9
Red River:						
Barbres Landing, La	Nov. 7	2.4	Aug. 24	5.3	Nov. 7	−1.0
Sugar House, La					Nov. 8	0.2
Atchafalaya River:						
Melville, La	Nov. 6	4.5	Aug. 25	7.3	Nov. 7	1.5
Simmsport, La	Nov. 7	2.0	Aug. 26	4.8	Nov. 8	−1.6
Mississippi River:						
Bayou Sara, La	Nov. 3	−2.1	Aug. 31	4.0	Nov. 11	−1.8
Baton Rouge, La	Oct. 28	2.5	Aug. 22	5.35	Nov. 10	1.2
Plaquemine, La	Nov. 5	1.5	Aug. 22	3.65	Nov. 13	0.2
College Point, La	Nov. 5	0.57	Aug. 22	2.22	Nov. 17	0.15
Carrollton, La	Oct. 28	0.4	Aug. 21	1.8	Oct. 21	−0.05
New Orleans, La	Nov. 6	2.3	Aug. 16	3.7	Nov. 16	2.2
Fort Jackson, La					Nov. 30	0.5

NOTE.—These are the corrected lowest gauge readings for fiscal year, July 1, 1890, to June 30, 1891.

The gauges of the district have been under the immediate charge of Assistant Engineer H. S. Douglas.

The low-water discharges at Red River Landing, Red River Dam, and Simmsport, and the high-water discharges at Natchez were taken by Assistant Engineer G. Ed. Mott.

The high-water discharge at Carrollton was taken by Assistant Engineer William Garvin.

High-water observations were made partly by Assistant Engineer W. G. Price and finished by Mr. B. J. Oliveira.

Their several reports are given herewith.

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SURVEYS, GAUGES, AND OBSERVATIONS.

Money statement.

July 1, 1891, balance unexpended	$5,700.50
May 9, 1892, transferred from Helena Harbor allotment	1,000.00
Total	6,700.50
May 31, 1892, expended during fiscal year to date	5,318.97
June 1, 1892, balance unexpended	1,381.53
In Treasury, United States	1,000.00
In hand	381.53
Balance available	1,381.53
Amount that can be profitably expended during fiscal year ending June 30, 1894	5,000.00

Discharge observations in the Mississippi River at Natchez, Miss.

Date.	Direction and force of wind.	Gauge.	Area.	Mean velocity per second.	Discharge per second.
1892.		*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*
May 16	Light: upstream	47.05	151,197.62	8.520	1,288,783.00
17	Strong; upstream	47.06	150,417.03	8.626	1,297,513.31
18	......do	47.16	158,807.45	7.341	1,166,244.14
19	Calm	47.16	153,124.54	8.493	1,300,523.71
20	......do	47.18	154,088.15	8.753	1,348,716.09
21	......do	47.14	152,188.47	8.801	1,339,516.18
23	Light; downstream	47.10	154,216.50	8.803	1,357,622.82
24*					
25	Brisk; upstream	47.07	153,065.33	8.645	1,323,305.10
26	Light; upstream	47.05	151,307.03	8.616	1,303,726.21
27	Strong; cross stream	47.04	155,215.65	8.468	1,314,394.69
28	Brisk; upstream	47.10	150,616.36	8.291	1,248,789.96
30	Strong; upstream	47.13	152,789.25	8.347	1,275,277.58
31	......do	47.19	151,042.09	8.587	1,296,969.49
June 1†					
2	Brisk; downstream	47.37	154,018.95	8.564	1,318,965.25
3	Light; downstream	47.41	158,795.50	8.414	1,336,106.14
4‡					
6	Light; downstream	47.40	153,384.37	8.724	1,338,150.49
7	......do	47.39	152,931.36	8.514	1,302,022.99

* No observation; tug disabled.
† No observation; tug disabled a. m.; heavy rain all p. m.
‡ No observation; tug in use on levee work.

G. ED. MOTT,
Observer.

Discharge observations in the Mississippi River at Red River Landing, La.

Date.	Gauge.	Area.	Mean velocity per second.	Discharge per second.	Slope.
1892.	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	
Apr. 3	33.50	166,307	4.243	705,587	....
5	34.21	168,680	4.549	767,372	1.043
7	34.96	167,806	4.717	791,496	1.042
21	40.60	192,490	5.102	982,150	0.913
May 4	43.78	199,575	5.313	1,060,313	0.923
6	44.09	201,717	5.325	1,074,084	0.988
11	44.79	207,180	5.315	1,101,164	0.959

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Discharge observations in the Atchafalaya River near Simmsport, La.

Date.	Gauge.	Area.	Mean velocity per second.	Discharge per second.
1892.	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*
Apr. 1	31.15	48,427	2.781	134,689
6	32.50	47,845	2.895	138,533
8	33.075	48,624	2.989	145,356
22	38.32	55,387	3.594	199,046
May 2	41.45	57,248	4.215	241,334
7	42.33	58,515	4.390	256,866
13	43.18	57,063	4.735	270,214

On May 14th the wind and waves were too strong for discharge work.

All the above discharges and mean velocities have been reduced by multiplying by .96, as the meter was run at mid-depth.

Respectfully submitted.

W. G. PRICE,
U. S. Assistant Engineer.

Discharge observations in the Mississippi River at Red River Landing, La.

Date.	Direction and force of wind.	Gauge.	Area.	Mean velocity.	Discharge.
1892.		*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*
May 19	Clear and calm	45.85	210,114	5.243	1,101,715
21	North; strong	45.40	211,455	5.220	1,103,786
23	Clear and calm	45.45	212,461	5.132	1,091,055
25	N. E.	45.50	214,505	5.184	1,111,987
27	S. W.; light	45.60	216,299	5.119	1,117,170
June 1	S. E.; raining	45.96	217,068	5.180	1,124,389
3	N. W	46.12	215,643	5.139	1,108,051
7	Clear and calm	46.50	218,804	5.155	1,127,831

Discharge observations in the Atchafalaya River near Simmesport, La.

Date.	Direction and force of wind.	Gauge.	Area.	Mean velocity.	Discharge.
1892.		*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*
May 20	Clear and calm	43.60	60,181	4.909	295,442
22	N. W.; strong	43.68	61,045	4.754	290,239
24	South	43.76	60,656	4.861	294,859
26	Clear and calm	43.81	61,357	4.770	292,674
28	S. E.; strong	43.90	60,981	4.900	299,170
June 2	N. W	44.40	62,567	5.055	316,261
4	Clear and calm	44.58	61,779	5.072	313,344
6	......do	44.82	61,903	5.176	320,415
8	......do	45.02	62,739	5.259	329,919

B. J. OLIVEIRA, *Observer.*

Discharge observations in the Mississippi River at Carrollton, La., 1892.

Date.	Weather.	Gauge.	Area.	Mean velocity.	Discharge.
1892.		*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*
May 14	Clear and calm	16.01	170,347.5	5.658	1,047,107.84
16	......do	16.15	178,740.0	5.407	1,028,627.30
18	......do	16.25	176,130.0	5.663	1,077,658.40
19	......do	16.10	176,615.0	5.602	1,106,559.75
21	......do	16.30	174,085.0	5.451	1,054,326.60
24	......do	16.30	176,911.0	5.393	1,050,936.64
27	......do	16.25	174,695.0	5.530	1,042,133.375
June 1	Strong S. wind	16.50	177,835.0	5.363	1,057,436.25
4	Clear and calm	16.60	181,418.0	5.484	1,098,891.797
6	......do	16.70	184,605.0	5.213	1,084,305.43
8	......do	16.70	182,059.0	5.403	1,102,810.95
10	......do	17.00	183,805.0	5.147	1,058,093.60
14	Strong NE. wind	16.70	184,776.5	5.226	1,088,836.055

WILLIAM GARVIN,
Assistant Engineer.

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NATCHEZ, MISS., *May 31, 1892.*

SIR: I have the honor to submit the following report on surveys, gauges, and observations under my immediate charge for the year ending May 31, 1892:

Surveys have been confined to personal examinations and reconnoissances of bank lines where existing levees were threatened by caving banks.

The gauges at St. Joseph, Bayou Sara, Plaquemine, College Point, and Fort Jackson on the Mississippi River, at Barbres and Sugar House Chute in Old River, at Simmesport and West Melville on the Atchafalaya, have been inspected from time to time, and are generally in as fair a state of efficiency as is practicable on caving and settling banks.

New bulletin boards have been set up at St. Joseph, Bayou Sara, Plaquemine, College Point, and Barbres Landing.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Lieut. JOHN MILLIS,
Corps of Engineers, U. S. A.

Approximate value of plant belonging to the United States and used upon the improvement of the Mississippi River, Fourth District.

Class of property.	Approximate value June 30, 1892.	Class of property.	Approximate value June 30, 1892.
Steamer General Newton	$12,000	One warehouse barge	$2,200
Steam launch Ruby	4,000	One warehouse barge	200
Steam tug General Comstock	6,500	Fifteen rowboats	200
Steam tug Tilda	6,000	Tools and appliances	16,000
Steam launch Alaska	3,500	Office furniture	1,500
Steam launch No. 5	2,000	Surveying instruments	2,600
One dredge boat	10,000	Drawing instruments	200
Four dump scows	12,000	Railway cars and tracks	1,900
Five quarter boats	12,000		
Twenty-six barges	45,000	Total	137,800

List of civilian engineers on work of river and harbor improvements in charge of First Lieut. John Millis, Corps of Engineers, to June 30, 1892, inclusive.

Name and residence.	Time employed. Mos.	Time employed. Days.	Compensation per month.	Where employed.	Work on which employed.
H. S. Douglas, New Orleans, La.	3	0	$200	New Orleans	Levees, Tensas Basin and gauges in district.
	9	0	200	Natchez, Miss	
W. G. Price, Schenevus, N. Y.	4	3	200	Simmesport, La	Red and Atchafalaya rivers, and surveys, gauges, and observations.
W. J. Hardee, New Orleans, La.	3	0	175	New Orleans	Levees right and left bank below Red River.
	9	0	175	Baton Rouge	
William Garvin, New Orleans, La.	9	25	150	New Orleans	New Orleans Harbor.
	1	10	175	do	Do.
G. Ed. Mott, New Orleans, La.	6	0	150	Simmesport, La., and Barbres, La.	Red and Atchafalaya rivers.
	3	0	150		

The following maps accompany and form a part of this report:

PLATE I.—General map of Fourth District.

PLATE II.—Works of improvement at junction of Mississippi, Red and Atchafalaya rivers.

PLATE III.—New Orleans Harbor.

PLATE IV.—Carrollton Bend, New Orleans Harbor, La.

PLATE V.—Third District Reach, New Orleans Harbor.

Very respectfully, your obedient servant,

JOHN MILLIS,
First Lieutenant of Engineers.

Col. C. B. COMSTOCK,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

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[To be inserted at page 3250 of Appendix XX, Annual Report Chief of Engineers, 1892.]

ERRATA IN REPORT OF THE MISSOURI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1892, APPENDIX XX, ANNUAL REPORT CHIEF OF ENGINEERS, 1892.

Page 3261, 15th line from bottom of page, for bordering read boring.
3263, Table 1, column 6, item 1, for 14,573.3 read 14,578.3.
3263, Table 2, column 4, item 4, for ---- read 10.
3263, Table 2, column 2, last item, for 53 read 54.
3263, Table 2, column 5, last item, for 3,893.20 read 3,893.28.
3265, Table 4, column 8, item 12 from bottom of page, for A. D. Bryan read A. S. Bryan.
3265, Table 4, column 5, item 10 from bottom of page, for 1887 read 1877.
3265, Table 4, column 7, items 6 and 7 from bottom of page, for do. read Mississippi and tributary rivers.
3266, Table 5, last column, item 11, for *50 read *5.00.
3266, Table 5, last column, item 12, for 15.25 read 19.25.
3266, Table 5, column 6, item 15, for 29 read 25.
3266, Table 5, column 7, item 15, for 2.6 read 3.6.
3267, Table 5, column 6, item 12, for 130 read 120.
3267, Table 5, column 7, item 13, for 100 miles read 10 miles.
3267, Table 5, column 8, item 15, for R. R. N. T. Co. read R. R. T. Co.
3267, Table 5, column 8, item 17, after Missouri insert River.
3269, Table 7, under Boilers, for Where built read When built.
3269, Table 7, column 3, item 3 from bottom of page, for $\left\{\begin{matrix}2\\1\text{–}7\end{matrix}\right\}$ read $\left\{\begin{matrix}2\\17\end{matrix}\right\}$
3270, In table, column 1, item 9, for Hossfield read Hossfeld.
3270, In table, column 4, item 24, insert *† before 3545.
3271, In table, column 5, item 3 from bottom, for $12\frac{16}{30}$ read 12.
3271, In table, column 5, item 2 from bottom, for 1 read $1\frac{16}{30}$.
3272, In table, column 1, item 23, for Rule read Rulo.
3282, Line 30 from bottom of page, for ability read stability.
3289, Line 23 from bottom of page, for No. 19 read No. 10.
3291, Line 8, for braeing read bracing.
3293, Line 4, for 222 read 221.
3293, In table, column 3, item 12, for 46.60 read 47.60.
3294, In table, column 1, paragraph 2, for 1,127 read 1,227.
3294, In table, column 4, item 5, for 1,101.75 read 1,101.79.

locality. The effect of the dikes constructed to protect the town front continues to be good and no further work seems to be needed.

Omaha, Nebraska.—At this locality the revetment of the left bank of the river near Council Bluffs, Iowa, was extended down stream 9,220

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NATCHEZ, MISS., *May 31, 1892.*

SIR: I have the honor to submit the following report on surveys, gauges, and observations under my immediate charge for the year ending May 31, 1892:

Surveys have been confined to personal examinations and reconnoissances of bank lines where existing levees were threatened by caving banks.

The gauges at St. Joseph, Bayou Sara, Plaquemine, College Point, and Fort Jack-

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Col. C. B. COMSTOCK,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

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APPENDIX X X.

ANNUAL REPORT OF THE MISSOURI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

OFFICE MISSOURI RIVER COMMISSION,
St. Louis, Mo., June 30, 1892.

SIR: The Missouri River Commission beg leave to submit herewith their annual report for the fiscal year ending June 30, 1892.

SURVEYS AND EXAMINATIONS.

The office work, computations, etc., connected with the secondary triangulation, which extends from the mouth of the river to the Three Forks in Montana, was completed.

Work in the field below Sioux City consisted in detached surveys to supply information not collected by the general survey of 1890, and to obtain information at special localities. This work was mainly carried on in the fall of 1891, and is described at length in the report of the secretary of the Commission (Appendix A).

In the spring of the current year two parties were placed in the field to run a line of precise levels between Sioux City, Iowa, and St. Charles, Mo., which latter point is already connected with the similar work done by the Mississippi River Commission and the U. S. Coast and Geodetic Survey. The work of these parties has progressed favorably, and it is expected that it will be completed during the current season.

Work has been continued on the mapping of recent surveys of the river. Twenty-one gauges have been maintained by the Commission, and the study and reduction of physical data has been continued.

For details see report of secretary of the Commission, Appendix A.

CONSTRUCTION.

For details see appendices, B, B1, C, and D.

Sioux City, Iowa.—No field work was done during the year at this locality. The effect of the dikes constructed to protect the town front continues to be good and no further work seems to be needed.

Omaha, Nebraska.—At this locality the revetment of the left bank of the river near Council Bluffs, Iowa, was extended down stream 9,220

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feet during the months of August, September, and October, 1891. This work, with that previously constructed, will, it is thought, sufficiently protect this bank, and that nothing more than occasional repairs will hereafter be needed.

Nebraska City, Nebraska.—No work was found necessary at this place during the season, and the plant was transferred to St. Joseph for service at that point. Eight thousand dollars of the balance of allotment for this place was transferred to the work at Bon Ton Bend.

St. Joseph, Missouri.—Work was resumed on the revetment of Belmont bend in the latter part of August, 1891, and was carried on during the fall, and to some extent during the winter and spring. Fourteen thousand two hundred and forty-six feet of revetment was constructed, and a junction effected with the work of previous years near Elwood, Kans. The work was not entirely completed and suffered considerable damage during the high water of the current year. As the original allotment for the work was about exhausted additional funds were transferred from the allotment for Council Bluffs revetment, and such repairs were made as were necessary to prevent further damage, the total extent of which can not be ascertained until the water falls.

Repairs were also made to the revetment in Bon Ton Bend, in which the construction of 3,000 feet of new revetment and numerous minor repairs proved necessary. Work was also carried on to some extent on the rectification works, pile dikes, above the St. Joseph Waterworks. The success of this work is not yet assured.

Atchison, Kansas.—No work has been done at this place during the year. The cut-off at Doniphan Point, alluded to in last report, has so far changed the regimen of the river that the works previously put in to direct and control the channel above the railroad bridge have suffered considerable damage, and their entire destruction seems to be only a question of time. Just what the final effect will be can not as yet be determined, but the direction of flow through the bridge still remains favorable.

Kansas City, Missouri.—Work in this neighborhood has been confined to repairing and completing the work of former years and was as follows, viz:

Little Platte Bend.—One thousand four hundred and fifty feet of revetment was constructed at this place, closing an open gap between the dikes at the upper end of the bend and the revetment already built at the lower end. The dikes themselves received slight repairs, and mattress aprons were placed around their outer ends to protect them from scour.

Kaw Bend.—Repairs were made to the revetment constructed in this bend in 1885 wherever weak places had developed themselves, and the work was placed in first-class shape.

Harlem revetment.—About 2,400 linear feet of the left bank above the Harlem system of dikes was protected by revetment during the fall of 1891.

East Bottoms revetment.—Some slight repairs were executed here, and consisted in resetting stone displaced by wave and ice action.

Kansas City and Harlem dikes.—These two systems of dikes are intended to control the flow of the river in front of Kansas City, and until their full effect is developed they will require repairs and extension from time to time. One thousand four hundred and twenty-four feet of dike was built during the past season, the work contemplated not being entirely completed.

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SYSTEMATIC IMPROVEMENT OF FIRST REACH.

In compliance with the wishes of Congress, as expressed in the last river and harbor bill, the systematic improvement of the river was begun last season in the vicinity of the mouth of the Osage River. Considerable time was required to close up minor works and get the plant together, and the study of this new locality and preparation of plans also involved much delay; nevertheless a fair start was made last summer, and considerable progress has been made. The extraordinary high water of the present season, which still continues, has been a serious drawback. The plan of work, so far as settled, consists in contracting the river and in confining it against the rocky right-hand shore from the vicinity of Jefferson City to the mouth of the Osage.

It had originally been intended to prolong this direction to Bonnots Mills, which would have involved occupying Osage Chute, but further examination having shown this course to involve considerable difficulties, a location outside of Dodds Island was finally decided on. The work so far consists entirely of pile dikes, of which about 16,500 linear feet have been constructed. So far as the effect of this work can now be observed the results have been very gratifying, though the low-water season must be awaited before definite conclusions can be reached. With the four-year appropriation provided in the river and harbor bill recently passed by Congress, it is hoped and expected that this work may be sufficiently extended to demonstrate effectually what results may ultimately be expected and what the cost of a thorough improvement of the river will be.

REMOVAL OF OBSTRUCTIONS.

The snag boat belonging to the Commission was set at work August 1, 1891, and continued at work until November 28, when she was laid up for the winter. Work was resumed March 22, 1892, and was carried on with various interruptions from high water, until May 21, when the great flood of this year caused a further suspension of operations. Work will be resumed as soon as the water recedes sufficiently to uncover the snags. During the season the boat worked over that portion of the river between the mouth and Boonville five times; between Boonville and Glasgow three times, and between Glasgow and Kansas City two times. One thousand nine hundred and forty-five snags were removed and destroyed, and great benefit conferred on navigation.

Table of work done by snag boat.

Name of river.	Snags destroyed.		Trees cut.	Drift piles removed.	Miles run.
	Number.	Estimated weight in tons of 2,000 pounds.			
Mississippi	....	....	....	....	136
Missouri	1,945	23,907.7	554	5	1,620
Total	1,945	23,907.7	554	5	1,756

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Money statement.

July 1, 1891, balance unexpended	$751,703.15
Cash received from overpayments refunded	94.27
	751,797.42
June 30, 1892, amount expended during fiscal year	549,980.67
July 1, 1892, balance unexpended	201,816.75
July 1, 1892, outstanding liabilities	33,057.93
July 1, 1892, balance available	168,758.82

Respectfully submitted.

CHAS. R. SUTER,
Lieut. Col. of Engineers,
President Missouri River Commission.
A. MACKENZIE,
Major of Engineers.
O. H. ERNST,
Major, Corps of Engineers, Colonel, U. S. A.
GARLAND C. BROADHEAD.
R. S. BERLIN.

The honorable the SECRETARY OF WAR.
(Through the Chief of Engineers, U. S. A.)

LETTER OF THE MISSOURI RIVER COMMISSION SUBMITTING ESTIMATES FOR THE FISCAL YEAR ENDING JUNE 30, 1894.

MISSOURI RIVER COMMISSION,
OFFICE OF THE PRESIDENT,
St. Louis, Mo., August 22, 1892.

GENERAL: The Missouri River Commission beg leave to submit the following estimate of the amounts that can be profitably expended during the fiscal year ending June 30, 1894, on the improvement of Missouri River between its mouth and Sioux City, Iowa:

Office and traveling expenses and salaries of Commission	$20,000
Surveys and observations	25,000
Gauges, physical data, and publications	25,000
Operating snag boat	35,000
Systematic improvement in first reach	645,000
Total	750,000

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Lieut. Col. of Engineers,
President Missouri River Commission.

The honorable the SECRETARY OF WAR.
(Through the Chief of Engineers, U. S. A.)

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Financial statement from July 1, 1891, to June 30, 1892.

Work.	Amount available July 1, 1891.	Refunded on account of overpayment.	Received by transfer from other allotments.	Totals.	Amount expended.	Transferred to other allotments.	Total expended and transferred, etc.	Total balances June 30, 1892.	Outstanding liabilities June 30, 1892.	Balances available June 30, 1892.
Survey of the Missouri River above the Missouri River Falls, Fort Benton, Mont	$111.77			$111.77	$111.77		$111.77			
Between Fort Benton, Mont., and Sioux City, Iowa:										
Surveys between Fort Benton and Sioux City	1,090.31	$1.72		1,092.03	1,092.03		1,092.03			
Between Sioux City, Iowa, and mouth of river:										
Office and traveling expenses and salaries of Commission	28,629.98	91.75		28,721.73	16,843.41		16,843.41	$11,878.32	$1,688.13	$10,190.19
Survey of Missouri River between Sioux City and the mouth	66.42	.80		67.22	67.22		67.22			
Improving Missouri River in vicinity of St. Joseph, Mo	9,528.51			9,528.51	9,528.51		9,528.51			
Sioux City, Iowa	7,622.25			7,622.25	6,239.90		6,239.90	1,382.35	315.00	1,067.35
Atchison, Kans	2,444.66			2,444.66	1,286.11		1,286.11	1,158.55		1,158.55
Extending and completing revetment in vicinity of Council Bluffs, Iowa	82,277.70			82,277.70	73,039.19	$3,000	76,039.19	6,238.51	702.72	5,535.79
Completion of revetment on Nebraska City Island	10,500.00			10,500.00	2,383.84	8,000	10,383.84	116.16	89.80	26.36
Continuation and completion of revetment in Belmont Bend	98,100.86		$2,500	100,600.86	97,942.59		97,942.59	2,658.27	2,054.87	603.40
Repair and maintenance of works in vicinity of Kansas City	60,728.26			60,728.26	44,734.04		44,734.04	15,994.22	43.00	15,951.22
Systematic improvement in First Reach	336,166.32			336,166.32	219,232.99		219,232.99	116,933.33	21,668.95	95,264.38
Maintenance of gauges, collection of physical data, and publications	18,503.55			18,503.55	10,845.06		10,845.06	7,658.49	1,459.23	6,199.26
Surveys and examinations between Sioux City and the mouth of the river	28,635.32			28,635.32	20,837.09		20,837.09	7,798.23	2,827.74	4,970.49
Care and repair of plant	5,754.76			5,754.76	5,754.76		5,754.76			
Removing obstructions in Missouri River from St. Joseph to mouth	61,542.48			61,542.48	32,411.65		32,411.65	29,130.83	1,799.59	27,331.24
Repair of revetment in Bor Ton Bend			8,500	8,500.00	7,630.51		7,630.51	869.49	408.90	460.59
Total	751,703.15	94.27	11,000	762,797.42	549,980.67	11,000	560,980.67	201,816.75	33,057.93	168,758.82

Detailed statement July 5, 1884, to June 30, 1892.

Work.	Balances of appropriations of 1882.	Appropriations and allotments.	From sales, etc.	Total available.	Expended to May 31, 1892.	Expended during the month of June, 1892.	Total expended to June 30, 1892.	Total balances June 30, 1892.	Outstanding liabilities June 30, 1892.	Balances available June 30, 1892.
Survey of the Missouri River above the Missouri River Falls, Fort Benton, Mont.		$15,000.00		$15,000.00	$15,000.00		$15,000.00			
Between Fort Benton, Mont., and Sioux City, Iowa.										
Office and inspection expenses of district officer	$2,000.00	$4,749.00		6,749.00	6,749.00		6,749.00			
Purchase and repair of plant	2,000.00	58,751.00		60,751.00	60,751.00		60,751.00			
Work below Fort Benton		31,500.00		31,500.00	31,500.00		31,500.00			
Improving Missouri River between Sioux City and Fort Benton		48,250.00	$0.75	48,250.75	48,250.75		48,250.75			
Survey between Fort Benton and Sioux City		73,250.00	1.72	73,251.72	73,251.72		73,251.72			
Office expenses and expenses of Commission		5,000.00	53.24	5,053.24	5,053.24		5,053.24			
Expenses proper of Commission, gauges, and physical data		3,500.00	20.62	3,520.62	3,520.62		3,520.62			
	4,000.00	225,000.00	76.33	229,076.33	229,076.33		229,076.33			
Survey of Missouri River from its mouth to Fort Benton	8,844.39			8,844.39	8,844.39		8,844.39			
Between Sioux City, Iowa, and mouth of river:										
Office and traveling expenses and salaries of Commission		85,000.00	709.11	85,709.11	72,641.20	$1,189.59	73,830.79	$11,878.32	$1,688.13	$10,190.19
Additional surveys and establishment of permanent bench marks below Sioux City		48,000.00		48,000.00	48,000.00		48,000.00			
Care of plant, preservation and observation of gauges, and collection and compilation of physical data		37,000.00		37,000.00	37,000.00		37,000.00			
Purchase of tow boat		1,100.00		1,100.00	1,100.00		1,100.00			
Improving Missouri River in vicinity of Kansas City (at Parkville, Mo.)		491,851.96	42.36	491,894.32	491,894.32		491,894.32			
Improving Missouri River in vicinity of St. Joseph, Mo		287,269.98	13.12	287,283.10	287,283.10		287,283.10			
Improving Missouri River in vicinity of Kansas City, Mo		106,150.00		106,150.00	106,150.00		106,150.00			
Construction of plant		57,064.84		57,064.84	57,064.84		57,064.84			
Special surveys		14,500.00		14,500.00	14,500.00		14,500.00			
Expenses proper of Commission, gauges, and physical data		33,800.00	188.97	33,988.97	33,988.97		33,988.97			
Survey of Missouri River between Sioux City and the mouth		33,775.00	.80	33,775.80	33,775.80		33,775.80			
Repair and care of plant		97,700.00		97,700.00	97,700.00		97,700.00			

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Omaha, Nebr	....	120,736.64	....	120,736.64	120,736.64	....	120,736.64	....	....	....
Sioux City, Iowa	....	80,411.67	....	80,411.67	79,029.32	....	79,029.32	1,382.35	315.00	1,067.35
Rulo, Nebr	....	39,980.49	....	39,980.49	39,980.49	....	39,980.49	....	....	....
Nebraska City, Nebr	....	60,298.92	....	60,298.92	60,298.92	....	60,298.92	....	....	....
Atchison, Kans	....	60,639.14	....	60,639.14	59,234.12	246.47	59,480.59	1,158.55	....	1,158.55
Leavenworth, Kans	....	60,213.71	....	60,213.71	60,213.71	....	60,213.71	....	....	....
Miami, Mo	....	19,787.67	....	19,787.67	19,787.67	....	19,787.67	....	....	....
Arrow Rock, Mo	....	36,294.98	....	36,294.98	36,294.98	....	36,294.98	....	....	....
Extending and completing revetment in vicinity of Council Bluffs, Iowa	....	82,000.00	....	82,000.00	74,401.57	1,359.92	75,761.49	6,238.51	702.72	5,535.79
Completion of revetment on Nebraska City Island	....	2,500.00	....	2,500.00	2,159 34	224.50	2,383.84	116.16	89.80	26.36
Continuation and completion of revetment in Belmont Bend	....	103,500.00	....	103,500.00	94,184.32	6,657.41	100,841.73	2,658.27	2,054.87	603.40
Repair and maintenance of works in vicinity of Kansas City	....	65,500.00	....	65,500.00	48,763.03	742.75	49,505.78	15,994.22	43.00	15.951.22
Systematic improvement in First Reach	....	348,000.00	....	348,000.00	190,665.93	40,400.74	231,066.67	116,933.33	21,668.95	95,264.38
Maintenance of gauges, collection of physical data, and publications	....	25,000.00	....	25,000.00	16,499.58	841.93	17,341.51	7,658.49	1,459.23	6,199.26
Surveys and examinations between Sioux City, Iowa, and the mouth of the river	....	55,000.00	....	55,000.00	43,943.16	3,258.61	47,201.77	7,798.23	2,827.74	4,970.49
Care and repair of plant	....	35,000.00	....	35,000.00	35,000.00	....	35,000.00	....	....	....
Repair of revetment in Bon Ton Bend	....	8,500.00	....	8,500.00	7,104.29	526.22	7,630.51	869.49	408.90	460.59
	....	2,496,575.00	954.36	2,497,529.36	2,269,395.30	55,448.14	2,324,843.44	172,685.92	31,258.34	141,427.58
Removal of snags and other obstructions (appropriation of 1886)	1,982.80	153,425.00	....	155,407.80	121,540.70	4,736.27	126,276.97	29,130.83	1,799.59	27,331.24
Grand tota	14,827.19	2,890,000.00	1,030.69	2,905,857.88	2,643,856.72	60,184.41	2,704,041.13	201,816.75	33,057.93	168,758.82

Consolidated statement, July 5, 1884, to June 30, 1892.

Act of July 5, 1884		$640,000.00
Act of August 5, 1886		375,000.00
Act of August 11, 1888		1,000,000.00
Act of February 22, 1890		75,000.00
Act of September 19, 1890		800,000.00
Total specific appropriations		2,890,000.00
Balances from former appropriations:		
Act of August 2, 1882, applied to works above Sioux City, Iowa	$4,000.00	
Survey Missouri River from mouth to Fort Benton	8,844.39	
Act of August 5, 1886, applied to removing obstructions from Missouri River	1,982.80	
Total balances		14,827.19
Received from sales and deposits		1,030.69
Total available		2,905,857.88
Expended to June 30, 1892		2,704,041.13
Balance June 30, 1892		201,816.75

List of civilian engineers employed on work of river and harbor improvements in charge of Missouri River Commission from July 1, 1891, to June 30, 1892, inclusive, under the river and harbor acts of July 5, 1884 (survey of Missouri River above Missouri River Falls, Fort Benton, Mont.), August 11, 1888 (improving Missouri River), and September 19, 1890 (improving Missouri River from its mouth to Sioux City, Iowa).

Name and residence.	Time employed. Mos.	Time employed. Dys.	Compensation per month.	Where employed.
Samuel H. Yonge, Kansas City, Mo	12	0	$250.00	Kansas City and Jefferson City, Mo.
S. Waters Fox, St. Joseph, Mo	12	0	250.00	St. Joseph, Mo.
Charles F. Potter, Omaha, Nebr	12	0	200.00	Omaha, Nebr.
O. B. Wheeler, St. Louis, Mo	10	20	200.00	St. Louis, Mo.
G. A. Marr, St. Louis, Mo	1	8	200.00	Do.
D. W. Wellman, St. Louis, Mo	3	0	200.00	In the field.*
J. A. Seddon, St. Louis, Mo	12	0	200.00	St. Louis, Mo.
A. H. Blaisdell, St. Louis, Mo	12	0	200.00	Do.
C. M. Winchell, St. Louis, Mo		16	187.50	In the field.*
	1	10	175.00	St. Louis, Mo.
	2	11	150.00	In the field.*
	5	20	150.00	St. Louis, Mo.
O. W. Ferguson, St. Louis, Mo	3	15	175.00	In the field.*
A. L. Johnson, St. Louis, Mo	3	15	150.00	Do.*
James A. Paige, St. Louis, Mo	3	0	175.00	Do.*
J. C. Meredith, St. Joseph, Mo	12	0	150.00	Rulo, Nebraska City, Nebr., and St. Joseph, Mo.
R. H. Bacot, Kansas City, Mo	12	0	150.00	Kansas City and Jefferson City, Mo.
Ed. Jones, Omaha, Nebr	4	21	125.00	Omaha, Nebr., and Sioux City, Iowa.
	7	0	100.00	Do.
W. G. Potter, Omaha, Nebr	2	21	90.00	Do.
	2	0	75.00	Do.
R. A. Crawford, Kansas City, Mo	12	0	125.00	Kansas City and Jefferson City, Mo.
Charles W. Campbell, St. Joseph, Mo		3	100.00	In the field.*
W. C. Simmons, Kansas City, Mo	2	10	100.00	Do.*
E. B. Wheeler, St. Louis, Mo	2	10	90.00	Do.*
A. H. Weber, Kansas City, Mo	12	0	125.00	Kansas City and Jefferson City, Mo.
L. P. Butler, St. Louis, Mo		10	137.50	In the field.†
	3	10	125.00	St. Louis, Mo.
	4	20	110.00	Do.
	1	11	100.00	In the field.*
E. D. Williams, St. Louis, Mo	12	0	100.00	St. Louis, Mo.
O. H. B. Turner, St. Louis, Mo	2	11	162.50	In the field.*
	2	21	150.00	Do.*
	4	22	137.50	St. Louis, Mo.
	2	6	125.00	In the field.*
J. G. Auld, St. Joseph, Mo	5	17	125.00	Do.*
Karl Widen, St. Louis, Mo		15	125.00	Do.†
Charles E. Taylor, St. Louis, Mo		15	125.00	Do.†
A. N. Darrow, St. Louis, Mo	4	22	150.00	St. Louis, Mo.
	8	0	137.50	Do.

* On survey of Missouri River. † On special survey.

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APPENDIX A.

ANNUAL REPORT OF SECRETARY MISSOURI RIVER COMMISSION, 1892.

OFFICE MISSOURI RIVER COMMISSION,
St. Louis, Mo., June 30, 1892.

SIR: I have the honor to submit the following annual report of the work in charge of the secretary of this Commission for the fiscal year ending June 30, 1892.

Very respectfully, your obedient servant,

J. C. SANFORD,
First Lieutenant of Engineers, Secretary.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

SURVEYS.

Secondary triangulation.—The field work of secondary triangulation over the entire length of the river was completed in December, 1890; but some office work remained to be done in the past year.

The geodetic coördinates of all the stations from Three Forks, Mont., to the mouth of the river, referring stations to parallels and meridians three minutes apart, for use in mapping, have been computed.

The elevations above sea level for stations between Three Forks, Mont., and Fort Benton, Mont., from vertical angles read at the stations, have been reduced, and are appended. (Appendix A 2.)

Shore-line survey below Sioux City, Iowa.—The rapid shore-line survey made in the fall of 1890 left unexamined considerable areas of back topography where cut-offs and other large changes in the position of the river had occurred since the survey of 1878–'79. To correct this topography two skiff parties were organized, the one leaving St. Joseph, Mo., on September 8, to work to the mouth of the river, the other leaving Sioux City on September 17, to work to Jones Point, Nebr. The first party completed their work November 12. The second party reached Jones Point October 13. This party had at Omaha been increased and reorganized, in order to make a complete shore-line survey, including back topography, from Jones Point to St. Joseph. A canvas-covered quarter boat had been prepared for the increased party at Omaha, and was used by them during the remainder of the season. The boat was similar to that described in the Annual Report of the Chief of Engineers for 1891, except that one of the small barges (64 by 16 feet) owned by the Commission formed the hull, and the dimensions of the canvas cover were 50 by 13 feet. This boat gave equally good satisfaction with that described in the above report, though used in a very different kind of river; so that I feel justified in repeating my commendation (Annual Report, 1891) of this class of boats. The work of the second party was completed December 9, and the party disbanded.

Special surveys.—At Three Forks, Mont., between September 17 and September 28, a small party made a survey of the numerous channels connecting the Jefferson and Madison rivers. They also roughly gauged the discharge of these rivers above the connecting sloughs, as well as below the junction of the two rivers, gauging likewise the Gallatin River and the Missouri River proper.

A special survey of the river in the vicinity of the bridge at Boonville, Mo., was made December 14–18, to determine the changes that had occurred in the channel in 1891.

The following special surveys were made under direction of the division engineers during the year:

- Sioux City, Iowa, from Milwaukee Point to the Chicago, St. Paul, Minneapolis and Omaha Railway Bridge.
- Sioux City, levels on dike lines.
- From the mouth of Boyer Creek, Iowa, to the Union Pacific Railway Bridge at Omaha, Nebr.
- Right bank in vicinity of Florence Lake, East Omaha.
- Nebraska City Reach, Nebraska and Iowa.
- Atchison Reach, Kansas and Missouri, partial shore-line survey.
- From mouth of Bee Creek, Missouri, to foot of Bee Creek Bend, near Fort Leavenworth, Kans.
- Vicinity of three coal dumps in the river at Leavenworth.
- Street lines at Kansas City, Kans., and Kansas City, Mo., connected with Missouri River survey stations.
- Kansas River at Riverview Bridge, Kansas City, Kans.
- From mouth of Kansas River to Hannibal and St. Joseph Railway Bridge, Kansas City, Mo.
- Dikes at Harlem, Mo.; outline survey of accretions.
- From 1¼ miles below Claysville, Mo., to Bonnots Mill, Mo.
- Lands of protesting landowners on Dodds Island, Mo., and in vicinity of Bonnots Mill, Mo.

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In addition to the above, numerous surveys and observations were made by the division engineers in the vicinity of Council Bluffs, Iowa, St. Joseph, Mo., and mouth of Osage River, Mo., with a view to laying out construction work, or to determine the effect of work under construction.

Mapping.—The notes of the survey of 1890, from Fort Benton, Mont., to Three Forks, Mont., 266 miles, have been platted on 32 detail maps (scale, 1 inch=400 feet). On the section between Stubbs Ferry and Sun River, covering 14 of these maps, topography and hydrography were omitted by the survey party, and were to be supplied from maps of the survey made in 1880 by Capt. Edward Maguire, Corps of Engineers. This hydrography has been transferred and inked. The topography has been transferred in pencil and is now being inked. Otherwise the 32 maps are nearly completed.

The platting of the notes of the shore-line survey of 1890, from Sioux City to the mouth of the river, 807 miles, was continued throughout the year. This survey covers 27 detail maps (scale, 1 inch = 1,000 feet), which are numbered from the mouth up. Little topography back from the shore line was taken on this survey, but the topography given on the detail maps of the survey of 1878–'79 was to be transferred to them, as well as all other recent topographical data on file in this office, or obtainable from outside sources. Much information of this kind has been obtained during the year through the courtesy of railroad companies whose lines are wholly or partly located in the valley. Detail maps Nos. 1 to 12, inclusive, and No. 16 are completed; Nos. 13, 14, 15, and 17 are nearly completed, while on the remaining maps considerable work yet remains to be done.

At the beginning of the fiscal year some work had been done on the maps of each of the above series, but no one map in either series was then completed.

The Commission decided in 1890 to publish a new series of charts (scale, 1 inch = 1 mile), giving the results of the shore-line survey of that year from Sioux City to the mouth, and to extend the series to include the entire length of the river. Ten such charts, extending from the mouth to Brunswick, Mo., 262 miles, have been completed ready for publication, the lower eight of which are in the hands of the photolithographers. The eleventh is in progress. The first chart above Fort Benton, covering 28 miles, and the first three below Fort Benton, covering 97 miles, are completed. The second chart above Fort Benton is in progress.

PRECISE LEVEL BENCH MARKS.

In 1887 a line of precise levels was run from the St. Louis City Directrix to United States Engineer P. B. M. 17 of Missouri River (published list of 1881), on the railway bridge at St. Charles, Mo. As early in the present season as practicable, two double precise level parties were sent into the field, with a view to carrying the line to Sioux City. In order to subsist the parties on quarter boats, it was necessary for each to begin work at the upper end of the section that it was to cover.

The length of the working season being considerably greater in the lower than in the upper part of the river, the lower section was made the longer, and extends from the United States boat yard at St. Joseph, Mo., to St. Charles, a river distance of 459 miles. The party to cover this section was placed in charge of Assistant Engineer O. W. Ferguson, who had also been in charge of the precise leveling of 1887. Work was begun at the St. Joseph boat yard on March 17, and at the close of the year the party had reached De Witt, Mo., 220 miles, river distance, from the head of the work. The following is a summary of the work done.

Miles of line leveled and checked	192.45
Precise bench marks, stone and pipe, set	38
Precise bench marks, copper bolts, set	42
Old bench marks, stone and pipe, connected with, and pipe replaced by new.	39
Other bench marks connected with	*31
City bench marks connected with	6
Gauges connected with	7

The second party, under Assistant Engineer James A. Paige, began work at Sioux City, April 16. Their line is to extend to the St. Joseph boat-yard, a river distance of 324 miles. At the close of the year this party had reached the United States boat yard at Council Bluffs, Iowa, 148 miles, river distance, below Sioux City (Big Sioux River).

The following is a summary of work done:

Miles of line leveled and checked	99.9
Precise bench marks, stone and pipe, set	42
Precise bench marks, copper bolts, set	1
Old bench marks, stone and pipe, connected with and pipe replaced by new.	13

*Five of these are U. S. Coast and Geodetic Survey bench marks.

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Each of these parties is subsisted on a canvas-covered quarter boat of the kind referred to under "surveys."

The stone and pipe bench marks set are of the pattern described in the Annual Report of the Chief of Engineers for 1887, page 2947, except that the pipe were expanded at the lower end, and iron flanges, or disks, 10 inches in diameter, were slipped down over the pipe, to prevent the pipe being pulled up or displaced.

The pipe of each of the stone-line bench marks connected with was taken up and replaced by an expanded pipe with flange.

The instructions given both parties differed but slightly from those issued by the Mississippi River Commission in 1891 (see Annual Report Chief of Engineers for 1891, p. 3476).

GAUGES AND PHYSICAL DATA.

At the beginning of the fiscal year, twenty-one permanent gauges were maintained by the Commission. The same number of such gauges are now maintained, one old gauge having beeen discontinued and one new gauge established during the year. The new gauge referred to was established at Townsend, Mont., in the latter part of September; and its readings began October 1. It is a standard cable gauge, and reads from 3785 feet to 3799 feet (elevations assumed above St. Louis City Directrix). The discontinued gauge was at Hermann, Mo., where a change in the channel had rendered the readings of little value. The Cole Creek gauge, 3¼ miles above, established in May, 1891, was intended to replace this; but the Hermann gauge readings were continued until January, 1892, in order to obtain the slope between the two points at different stages.

A temporary gauge has also been maintained since July 5, 1891, at Ewings Landing, Mo., by the construction party on First Reach.

About the middle of May, 1892, continued heavy rains produced a flood in the Missouri River nearly equaling those of 1881 and 1883; and, in order to obtain all possible comparable data connected with it, the old gauges at Hermann, Mo., Randolph, Mo., Leavenworth, Kans., St. Joseph Waterworks, Mo., White Cloud, Kans., and Sioux City (Perry Creek), Iowa, were temporarily reëstablished. They will be continued only until the close of the present high-water season.

In order to prevent loss of readings due to accidents to the wire cable gauges, each observer of such a gauge was furnished, in August, 1891, with a duplicate gauge, ready for immediate use if required. Only one of these duplicate gauges has thus far been called into use.

The system of monthly inspection of the gauges in the three divisions by assistants detailed by the division engineers, respectively, which has been followed for several years, has been found defective in this, that it frequently interfered seriously with the regular duties of these assistants. It was therefore decided in March, 1892, to place the inspections under the direct supervision of this office. Assistant Engineer L. P. Butler was detailed for this duty, and has performed his work in a very satisfactory manner.

A more detailed account of the year's gauge work will be found in the report of Assistant Engineer A. H. Blaisdell (Appendix A 3). Accompanying his report are given tables showing the heights reached by the high waters of 1844, 1881, 1883, and 1892, as well as a hydrograph from which these heights can more readily be traced.

The elevations of the lowest points in the superstructure of all high bridges between Rulo, Nebr., and the mouth of the river, excepting the bridge at St. Charles, Mo., have been remeasured in order to verify and correct the measurements published in 1889; but it is not considered advisable to publish the heights obtained until the results of the precise leveling now in progress are known. The remaining high bridges below Sioux City will be remeasured as soon as practicable.

Such information relative to borings in the Missouri Valley as has been obtained since the publication in the Commission's Annual Report for 1890 of all bordering data then obtainable is published herewith. It comprises the results of borings on line of proposed bridge near Wolfs Point, Mo. (plate A); on line of proposed bridge at East Omaha, Nebr. (plate B); and in the vicinity of the mouth of the Osage River, Missouri (plates C, C′, and C″). All of the information obtained in regard to the first two localities is shown on the plates. In his report on the third series Division Engineer Samuel H. Yonge, under whose direction the borings were made, says: "Borings were taken on 13 sections. They are 112 in number, with a total penetration of 3,225 feet.

"The borings do not indicate the presence of any materials in the trace of the proposed channel that may not be expected to yield to scour or that would prevent a sufficient enlargement of section to pass the entire discharge of the river at a stage of 4 feet above standard low water or 110.8 feet within the width proposed, viz., 1,000 feet. Section B, in Osage Chute, will probably enlarge by the erosion of Dodds Island as well as by scour.

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"As the tracings are fully lettered, and the positions of the different kinds of materials through which the borings are made are plainly marked, no explanation of them is thought necessary."

Discharge measurements, in addition to those mentioned under "Special surveys," have been made during the year, as follows: By Division Engineer Yonge, in the vicinity of the mouth of the Osage River, and at Jefferson City, Mo.; by Assistant Engineer James A. Seddon, near St. Charles, Mo.

Slope observations were also made by Division Engineer Yonge in the vicinity of the mouth of the Osage River.

Assistant Engineer Seddon has continued, during the year, the study of gauge relations. In this study he has shown that flood movement on the Lower Mississippi, from Cairo down, follows a very definite and simple law. This study will be continued until the determination of the exact movement of floods is carried up the Missouri and the Upper Mississippi rivers. Details of his work are given in his report (Appendix A 4).

COMMERCIAL STATISTICS.

An effort has been made to obtain, for the calendar year 1891, more reliable statistics of the amount of commerce on the Missouri River, between Sioux City and the mouth, than had been obtained in previous years. Greater classification was attempted, and the freight business was reduced to mile-tons.

List of the steamers enrolled at the custom-houses at St. Louis, Mo., Kansas City, Mo., St. Joseph, Mo., and Omaha, Nebr., and plying on the Missouri River in 1891, were first obtained from the surveyors of customs at those ports. The lists included the names and addresses of the owners, and to each of these a circular was sent asking the amount of business done by his boat during the year. Accompanying the circulars were forms, to assist in classification. In cases where the replies to these circulars were not sufficiently definite, the owners were visited in person.

The owners of many of the boats keep no detailed record of their business. For these boats the figures obtained are necessarily estimates; but unusual care was taken to make the estimates as close as the available data would permit.

The results obtained are appended (Appendix A 1).

ESTIMATES.

Office and traveling expenses and salaries of Commission	$20,000
Surveys and observations	25,000
Physical data and publications	20,000
Gauges	10,000
Total	75,000

Appendix A 1.

REPORT ON THE COMMERCE OF MISSOURI RIVER DURING YEAR 1891.

Office Missouri River Commission,
St. Louis, Mo., June 30, 1892.

Sir: I have the honor to submit the following report on the commerce of the Missouri River between Sioux City and the mouth, during the calendar year 1891:

The methods employed in obtaining statistics of commerce for 1891 was similar to that followed for 1890; but, as the length of time that could be devoted to this purpose was greater this year than formerly, it was possible to make a much more thorough classification of freight business done, and to reduce it to mile-tons. Lists were first obtained from the surveyors of customs at St. Louis, Mo., Kansas City, Mo., St. Joseph, Mo., and Omaha, Nebr., giving the names of all steamboats enrolled at those points in 1891, and plying on the Missouri River below Sioux City in that year; giving also the names and addresses of owners, and various detailed information regarding the boats, all of which is included in Tables 4–7. A circular was then sent to each steamboat owner, with accompanying forms; and he was requested to furnish this office with a statement of business done by his boat, classified as indicated on the forms. In most cases replies to these circulars were received, though frequently the replies were so indefinite that a personal visit to the boat owner was necessary. In the latter case it was generally found that no detailed record of the boat's business

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was kept; and an estimate of it, based on all available data, was made. The packet owners, on the other hand, keep very detailed records of their business; but owing to the great amount of work necessary in classifying their business, preferred to lend their freight books to this office, in order that the work might be performed here; or to permit it to be done on board the boats by an assistant from this office. In this way accurate statistics of the packet business were obtained.

The business done by boats engaged in short-trip coasting trade and in towing is also, for the most part, furnished from records and is quite reliable. That done by ferryboats, which I have included, is mainly estimated; but the estimates are believed to be close.

The following table represents the amount of freight carried, towed, and rafted in 1891, and the number of passengers:

TABLE 1.

	Grain.	Live stock.	Wood, lumber, and railroad ties.	Sand and building materials.	Miscellaneous farm produce and general merchandise.	Teams transported, including loads.	Totals.	Mile-tons.	Passengers.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*		*No.*
Long-trade packets	13,241.5	2,023.4	1,551.3	63.9	14,573.3	....	31,458.4	6,437,472.8	6,000
Short-trade packets and miscellaneous steamers	42,947.2	2,053.6	16,605.2	8,091.2	4,169.1	23.8	73,890.1	1,455,651.4	8,000
Sand and wood steamers and barges	....	....	3,336.6	67,716.7	50.0	....	71,103.3	145,868.7	....
Steam ferries	2,706.3	32,604.6	4,076.5	4,994.5	20,631.6	398,604.4	463,617.9	504,161.5	635,627
Cable, horse, and car ferries	....	5,918.7	....	....	594.3	25,196.7	31,709.7	32,209.7	53,925
Rafts	....	....	3,118.1	....	....	....	3,118.1	158,262.3	....
	58,895.0	42,600.3	28,687.7	80,866.3	40,023.3	423,824.9	674,897.5	8,733,626.4	703,552

The total freight business for 1890 was stated in my report of last year as 560,557 tons and was not classified. Part of the apparent increase for 1891 is probably due to the greater time and attention given to obtaining statistics for that year; but there has undoubtedly been a large increase in the long-trade packet business, and a still greater increase is looked for in the present year.

The following table shows the number and total registered tonnage of Missouri River steamboats enrolled at St. Louis and Missouri River ports below Sioux City for the years 1889, 1890, and 1891:

TABLE 2.

Enrolled at—	1891.		1890.		1889.	
	No.	*Tons.*	*No.*	*Tons.*	*No.*	*Tons.*
St. Louis, Mo	19	2,504.31	18	1,840.61	16	1,812.66
Kansas City, Mo	18	3,398.13	17	1,270.33	15	1,626.26
St. Joseph, Mo	5	265.41	5	277.62	5	277.62
Omaha, Nebr	12	794.21	....	504.72	13	1,329.55
Total	53	6,962.06	50	*3,893.20	49	5,046.09

*The totals for 1890 do not include the steamer *State of Kansas*, 1,130.34 tons, which, though engaged in Missouri River trade in that year, was enrolled at Louisville, Ky. The totals for that year should be 51 steamboats and 5,023.62 tons.

The steamboats engaged in Missouri River trade are employed as packets, in short-trip coasting trade, as towboats, as excursion boats, or as ferryboats. Nearly all of them are at different times employed for a variety of purposes.

The gauge-observers under the Commission record and report weekly the number and names of steamboats passing their respective gauges. From these reports and from the known tonnage of the boats the following table is made up:

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TABLE 3.

Locality.	Number of steamers passed.		Registered tonnage.	
	Up.	Down.	Up.	Down.
St. Charles, Mo	110	112	43, 378.03	43, 103.56
Hermann, Mo	179	181	45, 927.63	45, 709.32
Jefferson City, Mo	99	102	38, 734.02	38, 634.00
Boonville, Mo	98	101	22, 401.73	22, 227.91
Kansas City, Mo	22	22	16, 713.91	16, 441.90
Sioux City, Iowa	42	43	5, 084.87	5, 129.36

The rates of insurance on the river, both for hulls and cargoes, has remained unchanged since July 1, 1889. These rates are so high as to be almost prohibitory.

NEW LINES OF TRANSPORTATION ESTABLISHED DURING THE FISCAL YEAR 1891–'92.

The steamer *John L. Ferguson*, which formerly was employed as a ferryboat at St. Charles, Mo., began running from St. Louis as a packet in September, 1891. During the remainder of that year her trips extended as far as Augusta, Mo., 81 miles, but in 1892 she has been running to Portland, Mo., about 138 miles. Dimensions, etc., of the *Ferguson* are given in Table 4. A company known as The Farmers' Packet and Transportation Company is to be incorporated in July, 1892, with a capital of $25,000, to operate the steamers *White Eagle* and *Blue Wing* on the Illinois and Missouri rivers. It is expected to make two trips a week to Beardstown, on the Illinois River, and to Portland, on the Missouri, although this schedule will probably be varied at times, in accordance with varying conditions of trade. Ordinarily the *White Eagle* will run on the Illinois and the *Blue Wing* on the Missouri. The measured tonnage of the *White Eagle* is 312.75 and that of the *Blue Wing* 111.82.

The *Gasconade*, referred to in last year's report, was completed in July, 1891, and has since been plying in short-trip coasting trade, in connection with the Missouri Pacific Railroad at Hermann, Mo. Dimensions, etc., of the *Gasconade* are given in Table 4.

The steamer *Helena*, 352.31 tons, employed in the packet trade between St. Louis and Rocheport, Mo., about 212 miles, and landings on the Osage River, was sunk in the Missouri, November 23, 1891, at the foot of Bon Homme Island, and was a total loss.

TABLE 4.—*List of steamers plying on the Missouri River, in the district of New Orleans, enrolled at the port of St. Louis, Mo., during the year 1891.*

Name.	Where built.	Year.	Date of last inspection.	Dimensions.			Total tonnage.
				Length.	Breadth.	Depth.	
				Feet.	*Feet.*	*Feet.*	*Tons.*
A. W. Ewing	Osage City, Mo	1878	Apr. 27, 1891	....	....	....	4
Benton	Pittsburg, Pa	1875	Aug. 15, 1891	197	33	5	394.08
Commodore	New Haven, Mo	1890	June 9, 1891	97	23.2	3.2	86.45
Edna	Boonville, Mo	1887	May 18, 1891	102.4	21.5	4.7	80.35
Fawn	Hermann, Mo	1880	Apr. 27, 1891	91.8	19.1	3.4	73
Frederick	Tuscumbia, Mo	1883	....do	96.4	14.3	3	82.51
Helena	Pittsburg, Pa	1878	July 9, 1891	194	33	4.5	352.31
John L. Ferguson	Grafton, Ill	1876	Oct. 22, 1891	111.6	26.6	3.6	79.81
John R. Hugo	Evansville, Ind	1879	Apr. 27, 1891	127	20	3	136.88
Little Eagle No. 2	Jeffersonville, Ind	1877	June 3, 1891	130.4	19.2	3.9	82.65
May Bryan	......do	1875	Dec. 1, 1891	115	28	4.5	97.40
Pin Oak	Hermann, Mo	1888	Apr. 27, 1891	95	17.5	2.2	43.05
Royal	......do	1884	....do	86.6	24	3	44.82
Randall	Sioux City, Iowa	1889	May 9, 1891	92	19	3	44.49
Statie Fisher	Jeffersonville, Ind	1875	Apr. 28, 1891	122	28.8	4.6	106.52
Black Diamond	Portland, Mo	1886	May 27, 1891	72.5	14.4	2.3	18.40
Gasconade	Hermann, Mo	1891	July 3, 1891	107.4	29.4	3.5	74.35
White Eagle	Lacrosse, Wis	1877	Apr. 24, 1890	238	29	3.8	312.75
John Bertram	Jeffersonville, Ind	1880	July 24, 1891	180	34	5	390.49

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TABLE 4.—*List of steamers plying on the Missouri River, in the district of New Orleans, enrolled at the port of St. Louis, Mo., during the year 1891*—Continued.

Name.	Staterooms.	Berths.	Passengers. Permitted to carry.	Passengers. First cabin.	Passengers. Steerage or deck.	Engines. Number.	Engines. Diameter.	Engines. Stroke.	Boilers. Number.	Boilers. Length.	Boilers. Diameter.
							Inches.	*Feet.*		*Feet.*	*Inches.*
A. W. Ewing	......	......	8	......	8	1	6	[illegible]	1	3	40
Benton	18	36	66	30	36	2	15½	5	3	24	38
Commodore	......	......	30	......	30	2	10	4	1	20	44
Edna	6	12	33	8	25	2	8	3½	1	14	44
Fawn	3	......	50	20	30	2	8	2	1	14	42
Frederick	4	13	28	13	15	2	7	2½	1	14	36
Helena	16	32	62	32	30	2	13½	5½	2	24	42
John L. Ferguson	......	......	20	......	20	2	11	4	1	16	42
John R. Hugo	5	9	40	10	30	2	8	3	1	16	42
Little Eagle No. 2	6	12	18	8	10	2	14	5	2	20	38
May Bryan	......	......	50	......	50	1	16	5	1	22	44
Pin Oak	......	......	20	......	20	2	8	2½	1	17	40
Royal	......	......	20	......	20	2	8	2½	1	12	36
Randall	8	16	32	12	20	2	9¼	3	1	16	42
Statie Fisher	......	......	25	......	25	1	16½	5	1	22	42
Black Diamond	......	......	10	......	10	2	6	3	1	14	30
Gasconade	3	6	35	5	30	2	9	3½	1	20	42
White Eagle	13	24	135	35	100	2	15½	5	2	28	40
John Bertram	......	......	......	......	......	2	20	6½	4	24	38

Name.	Boilers. Flues. Number.	Boilers. Flues. Diameter.	Boilers. Steel or iron.	Boilers. When built.	Boilers. Steam pressure allowed.	Licensed to run on—	Name and address of sole or managing owner.
		In.			*Lbs.*		
A. W. Ewing	70	1¼	Steel	1885	125	Mississippi and tributary rivers.	C. C. Turner, St. Louis, Mo.
Benton	6	13½	Iron	1875	125	....do	Robert Roehrig, Washington, Mo.
Commodore	6	{2–12, 4–6}	Steel	1890	153	....do	S. H. Schlief, New Haven, Mo.
Edna	10	6	Steel	1887	160	....do	L. C. Lohman, Jefferson City, Mo.
Fawn	4	{2–10, 2–12}	Iron	1877	110	....do	William L. Heckmann, Hermann, Mo.
Frederick	6	6	Iron	1883	150	....do	Henry Castrop, Tuscumbia, Mo.
Helena	10	10	Steel	1878	159	....do	A. D. Bryan, Washington, Mo.
John L. Ferguson	12	5	Iron	1864	91	....do	Austin Owen, St. Charles, Mo.
John R. Hugo	5	10	Iron	1882	119	....do	R. M. Marshall, Tuscumbia, Mo.
Little Eagle No. 2	10	8	Iron	1887	151	....do	Southern Transportation and Lumber Co.
May Bryan	5	{2–12, 3–10}	Iron	1875	113	Missouri River	Washington Ferry Co., Washington, Mo.
Pin Oak	36	3	Steel	1888	125	Missouri and tributary rivers.	William L. Heckman, Hermann, Mo.
Royal	5	7	Steel	1884	125	....do	Do.
Randall	6	{2–10, 4–6}	Steel	1889	142	....do	Henry La Barge, St. Louis, Mo.
Statie Fisher	5	10	Steel	1875	140	Missouri river	Capital City Ferry Co., Jefferson City, Mo.
Black Diamond	21	3	Steel	1886	130	Mississippi and tributary rivers.	L. C. Lohman, Jefferson City, Mo.
Gasconade	5	6–10	Steel	1891	160	....do	Hermann Ferry and Packet Co., Hermann, Mo.
White Eagle	4	13	Steel	1890	169	....do	Hawkeye Steamboat Co., Burlington, Iowa.
John Bertram	......	......	Iron	1880	150	....do	St. L., K. & N. W. R. R. Co.

TABLE 5.—*List of steamers plying on the Missouri River, in the district of New Orleans, enrolled at the port of Kansas City, Mo., during the year 1891.*

Name.	Where built.	Year.	Date of last inspection.	Dimensions. Length.	Breadth.	Depth.	Total tonnage.
				Feet.	*Feet.*	*Feet.*	*Tons.*
A. L. Mason	Madison, Ind	1890		252	52.6	6	1,130.34
Aggie	Manchester, Ohio	1875		92.4	20.4	3	88.51
Alda	Boonville, Mo	1891	July 23, 1891	121	21.2	4	73.80
Annie Cade	Leavenworth, Kan	1879	May 21, 1891	127.5	32	4.5	178.32
Annie Lewis	Glasgow, Mo	1879	....do	93.4	27	4.2	81.14
Argentine	Kansas City, Mo	1886	....do	47	17.6	3.3	21.86
Carrie	St. Louis, Mo	1881	May 14, 1891	75	13	2	29.82
City of Brunswick	Brunswick, Mo	1890	Aug. 12, 1891	87.9	19.6	3.9	78.80
Jennie Gilchrist	Leclaire, Iowa	1871	May 21, 1891	105.5	18.5	3.8	74.40
Jos. L. Stephens	Jeffersonville, Ind	1887	May 18, 1891	103	29.4	4.2	85.95
Krata	St. Louis, Mo	1888	May 21, 1891				*50
Lillie Maud	Dewitt, Mo	1887	May 19, 1891	53.3	11.8	3.5	15.25
Mattie Lee	Grafton, Ill	1881	....do	110	28	4	104.81
Plow Boy	Sioux City, Iowa	1884	May 18, 1891	77.7	21.4	5.6	29.22
Roy Lynds	Jeffersonville, Ind	1887	May 20, 1891	87	29	2.6	66.09
St. Elmo	Dewitt, Mo	1891	June 12, 1891	57	17.4	3	28.01
State of Kansas	Madison, Ind	1890	Aug. 10, 1891	252	52.6	6	1,130.34
Vint Stillings	Metropolis, Ill	1881	May 22, 1891	131	31.6	4.8	177.47

Name.	State rooms.	Berths.	Passengers. Permitted to carry.	First cabin.	Steerage or deck.	Engines. Number.	Diameter.	Stroke.	Boilers. Number.	Length.	Diameter.
							Inches.	*Feet.*		*Feet.*	*Inches.*
A. L. Mason	11	22	100	50	50	2	20	7	4	28	42
Aggie						2	12	$3\frac{1}{2}$	2	16	36
Alda					50	2	10	5	1	22	42
Annie Cade						1	$20\frac{5}{16}$	$5\frac{1}{2}$	2	16	42
Annie Lewis						1	$15\frac{1}{2}$	5	1	18	46
Argentine						1	8	1	1	12	40
Carrie						2	6	2	1	12	30
City of Brunswick	4	12		8	17	2	8	3	1	16	44
Jennie Gilchrist					8	2	12	3	2	20	31
Jos. L. Stevens						2	10	$3\frac{1}{2}$	1	16	48
Krata						2	$5\frac{1}{2}$	$\frac{12}{12}$	1	12	40
Lillie Maud						1	6	1	1	$4\frac{1}{2}$	40
Mattie Lee	2	4			30	1	16	$4\frac{1}{2}$	1	20	48
Plow Boy					10	2	8	2	1	14	40
Roy Lynds						2	9	3	1	18	42
St. Elmo					25	2	7	3	1	12	40
State of Kansas	11	22	125	50	75	2	20	7	4	28	42
Vint Stillings						1	20	5	2	22	42

*Estimated.

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TABLE 5.—*List of steamers plying on the Missouri River, in the district of New Orleans, enrolled at the port of Kansas City, Mo., during the year 1891*—Continued.

Name.	Boilers.					Licensed to run on—	Name and address of sole or managing owner.
	Flues.		Steel or iron.	When built.	Steam pressure allowed.		
	Number.	Diameter.					
		In.			*Lbs.*		
A. L. Mason	16	10	Steel	1890	160	Mississippi and tributary rivers.	Kansas City and Missouri River Transportation Co., Kansas City, Mo.
Aggie	4	12	Iron	1875	106	Mississippi and tributary rivers.	Craig & McRoberts Sand Co., Kansas City, Mo.
Alda	10	6	Steel	1891	153	Mississippi and tributary rivers, 2,000 miles and return.	A. B. Eads and others, Boonville, Mo.
Annie Cade			Iron	1879	119	Missouri River at Kansas City and opposite shore, 5 miles above and below.	Wm. A. Cade, Leavenworth, Kans.
Annie Lewis			Iron	1879	113	Missouri River between ferry crossings.	Wm. D. Ward, Independence, Mo.
Argentine	39	3	Steel	1886	100	Missouri River and tributaries, 10 miles above and below Kansas City, Mo.	Argentine Sand Co., Kansas City, Mo.
Carrie	26	2½	Iron	1881	110	Missouri River and tributaries.	Argentine River Improvement and Traffic Co., Argentine, Kans.
City of Brunswick	10	6	Steel	1890	141	Mississippi River and tributaries.	Brunswick Ferry and Packet Co., Brunswick, Mo.
Jennie Gilchrist	10	6	Steel	1879	169	Mississippi River and tributaries, 2,000 miles and return.	Argentine Sand Co., Kansas City, Mo.
Jos. L. Stevens			Steel	1887	125	Missouri River to opposite shore at ferry crossings.	John Porter, Boonville, Mo.
Krata	53	2.03	Iron	1884	80	Missouri River and tributaries, 2,000 miles and return.	Hale Chapman, Armourdale, Kans.
Lillie Maud			Steel	1889	130	Missouri River and tributaries, 2,000 miles and return.	Sam'l. B. Casebolt, Dewitt, Mo.
Mattie Lee	6	{2.14 / 4.8}	Iron	1881	130	Missouri River at Miami and 100 miles above and below.	John Burruss, Miami, Mo.
Plow Boy	40	3	Steel	1889	150	Mississippi River and tributaries, 2,000 miles and return.	Wm. Hulett, Rocheport, Mo.
Roy Lynds			Steel	1887	125	Missouri River at Lexington, Mo., and opposite shore.	Lexington Ferry, Coal and R. R. N. T. Co., Lexington, Mo.
St. Elmo			Steel	1891	155	Missouri River and tributaries, 1,000 miles and return.	Samuel B. Casebolt, Dewitt, Mo.
State of Kansas	16	10	Steel	1890	160	Mississippi River and tributaries.	Kansas City and Missouri Transportation Co., Kansas City, Mo.
Vint Stillings			Iron	1878	135	Missouri River at Leavenworth, Kans., and opposite shore, 6 miles above and below.	Vinton Stillings, Leavenworth, Kans.

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TABLE 6.—*List of steamers plying on the Missouri River, in the district of New Orleans, enrolled at the port of St. Joseph, Mo., during the year 1891.*

Name.	Where built.	Year.	Date of last inspection.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Depth.	Total tonnage.
				Feet.	*Feet.*	*Feet.*	*Tons.*
John M. Abbott	Madison, Ind	1883	May 22, 1891.	92	20	3.6	97.78
Belle of Brownville.	Grafton, Ill	1880	....do	110	30	4	102.44
Harry Clyde	New Frankfort, Mo	1889	Nov. 28, 1891	60.9	23.3	3.3	23.79
Minnona	Riverside, Nebr	1884	May 23, 1891.	70	18	3	22.04
J. K. Yazel	Atchison, Kans	1886	....	44	12	$3\frac{8}{12}$	19.36

Name.	Staterooms.	Berths.	Passengers. Permitted to carry.	Passengers. First cabin.	Passengers. Steerage or deck.	Engines. Number.	Engines. Diameter.	Engines. Stroke.	Boilers. Number.	Boilers. Length.	Boilers. Diameter.
							Inches.	*Feet.*		*Feet.*	*Inches.*
John M. Abbott	......	......	17	......	17	2	9	4	1	20	42
Belle of Brownville.	......	......	......	......	......	1	16	4	1	18	48
Harry Clyde	......	......	20	......	20	2	6	2	1	11	30
Minnona	......	......	......	......	......	1	7	$\frac{10}{12}$	1	7	30
J. K. Yazel	......	......	......	......	......	1	8	1	1	$11\frac{3}{8}$	34

Name.	Boilers. Flues. Number.	Boilers. Flues. Diameter.	Boilers. Steel or iron.	Boilers. When built.	Boilers. Steam pressure allowed.	Licensed to run on—	Name and address of sole or managing owner.
		In.			*Lbs.*		
John M. Abbott	6	{ 6 / 10 }	Iron	1883	142	Mississippi and tributary rivers.	Wm. H. Floyd, jr., St. Joseph, Mo.
Belle of Brownville.	....	....	Steel	1880	145	Missouri River between St. Joseph, Mo., and opposite shore.	F. J. Clarkson, Elwood, Kans.
Harry Clyde	....	....	Steel	1884	100	Mississippi and tributary rivers.	C. H. Douglas, Nemaha, Nebr.
Minnona	....	....	Iron	1883	120	Missouri River at ferry crossings.	John H. Lynds, White Cloud, Kans.
J. K. Yazel	28	3	Steel	1887	120	Missouri and tributary rivers.	C. F. Etherton, St. Joseph, Mo.

TABLE 7.—*List of steamers plying on the Missouri River, in the district of New Orleans, enrolled at the port of Omaha, Nebr., during the year 1891.*

Name.	Where built.	Year.	Date of last inspection.	Dimensions. Length.	Dimensions. Breadth.	Dimensions. Depth.	Total tonnage.
				Feet.	*Feet.*	*Feet.*	*Tons.*
Abner O'Neal	Freedom, Pa	1884	Apr. 11, 1891	150	28.4	3.8	197.74
Andrew S. Bennett.	Sioux City, Iowa	1880	Aug. 20, 1890	115	30	3.5	78.08
Capitola Butt	Montrose, Iowa	1885	May 23, 1891	83.7	23.3	3.3	57.31
Josie L. K	Chamberlain, S. Dak	1884	Aug. 20, 1890	60	14	2.5	22.75
Last Chance	Burlington, Iowa	1870	Oct. 17, 1891	98.2	17.8	3	50.47
Liberty	Chicago, Ill	1887	May 26, 1891	....	....	....	3.00
Little Maud	Sioux City, Iowa	1882	June 25, 1890	92	20	3.4	58.66
Mary E. Bennett	Covington, Nebr	1888	May 25, 1891	65	14	2	21.71
Queen No. 2	Tieville, Iowa	1879	Aug. 21, 1891	44	12	2	12
Sioux	Waukegan, Ill	1888	Aug. 21, 1890	....	....	....	3
D. P. Rolf	Nebraska City, Nebr	1891	May 23, 1891	....	....	....	4
Rosebud	Pittsburg, Pa	1877	....	177.4	31.3	4	286.49

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TABLE 7.—*List of steamers plying on the Missouri River, in the district of New Orleans, enrolled at the port of Omaha, Nebr., during the year 1891*—Continued.

Name.	Staterooms.	Berths.	Passengers. Permitted to carry.	Passengers. First cabin.	Passengers. Steerage or deck.	Engines. Number.	Engines. Diameter.	Engines. Stroke.	Boilers. Number.	Boilers. Length.	Boilers. Diameter.
							Inches.	*Feet.*		*Feet.*	*Inches.*
Abner O'Neal	16	34	46	34	12	2	14	5	2	20	42
Andrew S. Bennett	......	......	75	......	75	2	11.5	4½	1	22	48
Capitola Butt	......	......	20	......	20	2	11	3½	1	20	46
Josie L. K	......	......	30	......	30	1	6	1	1	5½	40
Last Chance	......	......	32	2	30	2	11	3	1	18	42
Liberty	......	......	10	......	10	1	5	7/12	1	3¾	36
Little Maud	......	......	......	......	......	2	10.5	3	1	26	40
Mary E. Bennett	......	......	50	......	50	2	{7.25 7.5}	2½	1	16	38
Queen No. 2	......	......	......	......	......	1	7.5	½	1	7½	30
Sioux	......	......	15	......	15	1	4.5	5/12	1	4	26
D. P. Rolf	......	......	10	......	10	1	.3	¼	1	3½	30
Rosebud	......	......	......	......	......	......	......	......	......	......	......

Name.	Boilers. Flues. Number.	Boilers. Flues. Diameter.	Boilers. Steel or iron.	Boilers. Where built.	Boilers. Steam pressure allowed.	Licensed to run on—	Name and address of sole or managing owner.
		In.			*Lbs.*		
Abner O'Neal	12	8	Steel	1884	170	Missouri River between Omaha and Fort Benton.	R. A. Talbott, Mandan, N. Dak.
Andrew S. Bennett	6	{2–14 4–7½}	Steel	1883	140	Mississippi River and tributary streams.	D. Ayers, Ponca, Dixon Co., Nebr.
Capitola Butt	10	8	Steel	1885	145	....do	Oliver F. and Wm. H. Butt, Nebraska City, Nebr.
Josie L. K	....	....	Iron	1880	125	....do	A. Larson and B. Drange, Yankton, S. Dak.
Last Chance	....	....	Iron	1870	83	....do	M. K. King, Chamberlain, S. Dak.
Liberty	86	{1½ 16}	Steel	1887	115	Missouri River and tributary streams.	E. E. French, Omaha, Nebr.
Little Maud	....	....	Steel	1889	156	Missouri River and tributaries between Running Water, S. Dak., and Niobrara, Nebr., as ferry-boat, and between Running Water and Fort Randall as freight boat.	Jos. Leach, Sioux City, Iowa.
Mary E. Bennett	5	....	Steel	1891	177	Mississippi and tributary rivers.	Wm. Luther, Covington, Nebr.
Queen No. 2	....	....	Iron	1877	110	Missouri River at ferry crossings.	B. F. Hull & Son, Decatur, Nebr.
Sioux	33	{2 1–7}	Steel	1888	100	Sioux River between mouth and head of navigation.	Sioux City and Highland Park R. R. Co.
D. P. Rolf	*90	{1½ 12}	Iron	1891	110	Mississippi and tributary rivers.	......
Rosebud	....	....	......	......	......	......	......

*Porcupine.

Very respectfully, your obedient servant,

J. C. SANFORD,
First Lieut. of Engineers, Secretary.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

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APPENDIX A 2.

ELEVATIONS ABOVE SEA LEVEL OF THE SURFACE OF THE GROUND AT THE SECONDARY TRIANGULATION STATIONS BETWEEN THREE FORKS, MONTANA, AND FORT BENTON, MONTANA (SURVEY OF 1890).

NOTE.—Elevations are in feet and depend upon the elevation of the Northern Pacific Railroad track at Gallatin, Mont., as given by the railroad levels, for height above sea level.

Results marked with an asterisk (*) are from a direct connection with a bench mark (published list of 1891), and those marked with a dagger (†) are from a continuous connection of reciprocal readings between stations. All readings or angles upon which the elevations depend are from one vernier and one pointing of the 10-inch limb theodolite used on secondary triangulation; but, in general, there are two or more routes for arriving at any one station.

The extreme limits of error are put at ± 10 feet.

Station.	Elevation.	Station.	Elevation.
South base (Gallatin)	*4035	Great Falls	†3498
North base (Gallatin)	*4024	N. Great Falls	†3530
Clark	†4421	Henry	†3460
Beattie	†4377	Porter	†3492
Magpie	†4335	Bromedy	†3422
Sawyer	†4282	Wolf Creek	†4455
Howard	†3942	Rock Creek	†4484
Reeves	†4184	Craig	†4282
Hossfield	†4104	Wagner	†3928
Pinnacle	†4905	Sugar Loaf	†5408
Carolus	†4313	Stickney	5116
Painted Rock	*†4780	Hardy	*†4968
Lone Bush	†5174	Sheep Creek	5900
Dougherty	†3906	Cascade	4016
Toston	†4988	St. Clair	*†3585
Willow Creek	5350	Muddy Creek	*†3620
Oxbow	5075	Divide	3720
Mitler	†5752	Ulm	*†3396
Deep Creek	†4204	Antelope	†3728
Bridge	†3876	Wilson	3768
Marks	†3960	Epler	3730
Reed	†3830	Big Bend	4070
Duck Creek	†4054	Sun River	*†3664
Beaver Creek	†4133	Sand Coulée	3545
Confederate	†4059	Transfer	†3578
Squires	†4027	Shepherd	3630
Geary	†3986	Sidney	3205
Degan	*†4263	Highwood	3430
Blackwell	†4000	Tunis	2980
Canyon Ferry	*†4666	Cherry	3265
Maxwell	5234	Early	†3393
Stubbs	†3842	Belt	3405
Fuller	†4866	Portage	3410
Prickly Pear	†4280	Teton	3100
Eldorado	4670	Benton	2965
Hilger	†5270	West base (Fort Benton)	*2870
American	5560	East base (Fort Benton)	*2885
Bear Tooth Mountain	†6775		

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APPENDIX A 3.

ANNUAL REPORT OF MR. A. H. BLAISDELL, ASSISTANT ENGINEER, 1892.

OFFICE MISSOURI RIVER COMMISSION,
St. Louis, Mo., June 30, 1892.

SIR: I have the honor to submit the following report on the water gauges maintained by the Missouri River Commission for the fiscal year ending June 30, 1892.

The following table gives the location of each gauge, its character, time maintained during the year, and the distance above the mouth of the river as measured on the channel lines of 1878–'79 and of 1890:

Location of gauge.	Character of gauge.	Miles above mouth measured on channel lines of— 1878–'79.	1890.	Months maintained during year.
St. Charles, Mo	Bridge, cable	25.1	28.06	12
Hermann, Mo	Shore, inclined	101.1	103.35	6 18/30
Do	......do	101.1	103.35	*1 18/30
Cole Creek, Mo	......do	104.7	107	12
Ewings Landing, Mo	Shore, cable	139.4	143.8	12
Jefferson City, Mo	Shore, vertical	145.5	151.0	12
Do	Shore, inclined	145.8	151.3	
Boonville, Mo	Bridge, cable	197.5	205.8	12
Glasgow, Mo	......do	226.5	237.5	12
Dewitt, Mo	Shore, inclined	262.5	267	9 1/2
Do	Shore, cable			2 1/2
Waverly, Mo	Shore, inclined	297.4	299.3	12
Lexington, Mo	......do	318.7	321	12
Sibley, Mo	Bridge, cable	347.6	350	12
Randolph, Mo	......do	382.3	386.7	1 19/30
Kansas City, Mo	......do	386.3	390.7	12
Leavenworth, Kans	Shore, vertical	416.8	421.8	1 14/30
Fort Leavenworth Bridge, Kans	Bridge, cable	418.9	424	12
Atchison, Kans	......do	445.8	447.8	12
St. Joseph, Mo	......do	479.5	479	12
St. Joseph Water Works, Mo	Shore, vertical	489.7	488.6	1 17/30
White Cloud, Kans	......do	530.8	525.4	1 15/30
Rulo, Nebr	Bridge, cable	542.1	567.5	12
Brownville, Nebr	Shore, cable	579.9	577.6	12
Nebraska City, Nebr	Bridge, cable	609.0	607.7	12
Plattsmouth Bridge, Nebr	......do	638.3	633.6	12
Omaha, Nebr	......do	667.8	659.1	12
Blair, Nebr	......do	700.6	694.6	12
Sioux City Bridge, Iowa	......do	800.9	805.7	12 18/30
Sioux City, Iowa (Perry Creeek)	Shore, vertical	802.8	807.4	1
Townsend, Mont	Bridge, cable	....	....	9

* Weather Bureau gauge (corrected).

The gauge at Ewings Landing was established by Division Engineer S. H. Yonge, and is maintained in connection with the works of improvement in progress on the First Reach.

Unusual rainfall occurring in April and May produced a flood comparable with those of 1881 and 1883; and, by order of the president of the Commission, the old gauges at Hermann, Randolph, Leavenworth, St. Joseph Water Works, White Cloud, and Sioux City (Perry Creek) were reëstablished for purpose of comparison and study of flood data.

They are still being maintained but will be discontinued when the present high water subsides.

For some years the inspection of the gauges, and also such repairs and renewals as were necessary, had been performed under the direction of the division engineers. This extra monthly duty occasionally interfered with the survey and other work on the divisions, and it was decided by you to assign the work to an assistant reporting directly to this office.

Mr. L. P. Butler, assistant engineer, was directed in March, 1892, to report for the field duty connected with the gauges, and is now returning from his third tour of inspection.

We have still every reason to regard the cable gauge as the standard form for the Missouri River. In order, however, to provide against all possibility of a broken record resulting from accident to the cable there was sent, by your direction, on August 15, 1891, to each cable-gauge station a duplicate gauge cord, weight, and index, which were adjusted to the proper lengths by the inspector, and made ready

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for immediate use. It was also decided to increase the size of the sash-cord cable from one-eighth inch diameter to three-sixteenths inch.

There has been no change in the system adopted for the permanent preservation of the records.

For the purpose of ready reference a condensed weekly abstract of the records is kept, copies of which are furnished to the steamboat service of the Commission. Monthly comparison of the readings of the Weather Bureau gauges on the river with those of the Commission have been made, with interchange of records.

The elevations of the zeros of the Weather Bureau gauges are as follows:

At Hermann, Mo., about 71.1 feet.

This equating number holds good for the lower 10 feet of the gauge. The upper section of the gauge, from 13 feet to 32 feet, is graduated wrongly, the average vertical height between feet marks being 0.873. The correct elevation of the 32-foot mark is 100.537 feet, and that of the 18-foot mark is 88.296 feet.

At Boonville, 152.143 feet.

At Kansas City, 303.35 feet.

At Plattsmouth no equating value appears obtainable, as this gauge is landlocked except in very high water.

At Omaha, 545.05 feet.

At Sioux City (Perry Creek), 663.8 feet.

Accompanying this report is a profile showing the relative high water elevations and points on the river between St. Charles and Sioux City for the years 1844, 1881, 1883, and the present year up to date.

This drawing can be considered as giving only relative heights attained by the water at gauge stations and not relative slopes, as the distances are measured on the channel line of 1890.

The following table gives the data from which the drawing was made; and also the dates when the water reached its maxium height, except in this year, when the river at all stations above White Cloud was still rising slowly on the 30th of June.

The Townsend, Mont., gauge, which is 219.3 miles by channel above Fort Benton, gave its maximum reading on June 22. This was 6.4 feet above the average and almost stationary height for 75 days preceding May 10.

Missouri River, relative high-water elevations, referred to the St. Louis city directrix.

	1844.	1881.		1883.		1892 to June 30.	
	Elevation.	Date.	Elevation.	Date.	Elevation.	Date.	Elevation.
	Feet.		*Feet.*		*Feet.*		*Feet.*
St. Charles, Mo	39.50	May 5	28.68	June 24	30.34	May 18	30.25
Hermann, Mo		May 4	91.79	June 24	92.54	May 15	92.82
Cole Creek, Mo						May 15	96.75
Ewings Landing, Mo						May 15	126.40
Jefferson City, Mo				June 23	133.15	May 15	131.00
Cedar City, Mo		May 4	133.19				
Boonville, Mo	184.80	May 3	175.41	June 23	175.39	May 14	175.30
Glasgow, Mo		May 3	201.45	June 23	202.77	May 15	199.55
Do						May 23	199.55
DeWitt, Mo				June 28	224.15	May 21	221,25
Waverly, Mo				June 27	252.45	May 21	249.32
Lexington, Mo		May 1	276.70	June 27	273.25	May 22	268.90
Sibley, Mo	310.96					May 22	291.75
Randolph, Mo						May 21	324.40
Kansas City, Mo	341.16	Apr. 30	331.10	June 26	327.85	May 21	328.30
Leavenworth, Kans		Apr. 29	352.97	June 26	349.58	May 21	347.65
Ft. Leavenworth Bridge, Kans						May 21	348.80
Fort Leavenworth, Kans		Apr. 29	356.77				
Atchison, Kans		Apr. 29	376.51	June 26	371.40	May 21	369.90
St. Joseph, Mo	400.62	Apr. 29	403.30	June 26	398.92	May 20	394.50
St. Joseph Waterworks, Mo						May 20	404.20
White Cloud, Kans		Apr. 28	438.82	June 24	436.92	May 20	431.15
Rule, Nebr						June 30	441.05
Brownville, Nebr		Apr. 27	481.94	June 24	478.40	June 30	476.00
Nebraska City, Nebr		Apr. 27	509.42	June 28	507.10	June 30	506.25
Plattsmouth Bridge, Nebr						June 30	538.45
Plattsmouth, Nebr		Apr. 25	574.40	June 28	541.90		
Omaha, Nebr		Apr. 25	569.71	June 28	560.00	June 30	560.10
Do				July 11	560.10		
Blair, Nebr			596.14	July 10	588.30	June 30	586.70
Sioux City Bridge, Iowa						June 30	677.70
Do						May 19	*679.90
Sioux City (Perry Creek)		Apr. 23	686.34	June 25	677.15	June 30	679.10
Do				July 10	677.20		

* From local flood in Floyd River Valley.

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After the completion of the lines of precise levels now in progress, and the correction of the elevations of the bench marks, the gauge data can be more confidently and thoroughly studied.

Very respectfully, your obedient servant,

A. H. BLAISDELL,
Assistant Engineer.

First Lieut. J. C. SANFORD,
Corps of Engineers, U. S. A.

APPENDIX A 4.

ANNUAL REPORT OF MR. J. A. SEDDON, ASSISTANT ENGINEER, 1892.

OFFICE MISSOURI RIVER COMMISSION,
St. Louis, Mo., June 30, 1892.

SIR: I have the honor to submit the following report on the study of physical data for the fiscal year ending June 30, 1892:

The work has consisted principally in continuing the study of flood movement; and in this it is thought that final results have been reached in the Lower Mississippi River from Cairo down. This has been made the subject of a special report, given as an appendix to the annual report of the Mississippi River Commission, where the data used belongs. For the characteristics of flood movement and the precision of its determination reference is made to that report.

From the report it is seen that the conclusions depend on the precision with which time intervals can be determined by trial gauge relations, and on the relations being extended over successively lengthening reaches without disturbances from tributary increments. On the Lower Mississippi it was found that the true intervals were determinate to the nearest tenth of a day (or to within about 1½ hours); and in favorable floods the relations were extended through seven gauges, covering over 300 miles of river. From this it follows that a flood wave is in a permanent shape, and moves down as a whole without change of form and at a fixed rate.

Prior to this investigation the study of gauge relations had been carried forward to about an equal extent over the Missouri and Lower Mississippi rivers, and to a somewhat less extent over the Upper Mississippi. In these studies the determination of time interval was only attempted to the nearest quarter of a day, and no systematic study of floods through successively lengthening reaches was made; but, as far as it went, the conclusion had been reached that the general characteristic of flood movement was the same in all the rivers, though there were material differences in the rates of travel.

It now remains for further investigation to determine whether the precision which characterizes flood movement found in the Lower Mississippi will be maintained in the upper rivers.

A short series of discharge observations in the vicinity of St. Charles, Mo., was taken on the flood of this year. These have been computed, and a preliminary study has been begun of the present variation of discharge to gauge in the lower rivers.

Very respectfully, your obedient servant,

J. A. SEDDON,
Assistant Engineer.

First Lieut. J. C. SANFORD,
Corps of Engineers, U. S. A.,
Secretary Missouri River Commission.

APPENDIX B.

ANNUAL REPORT OF MR. CHARLES F. POTTER, DIVISION ENGINEER, 1892.

MISSOURI RIVER COMMISSION, OFFICE OF DIVISION ENGINEER,
Omaha, Nebr., June 15, 1892.

COLONEL: I have the honor to submit the following report of operations under my charge at Sioux City, Iowa, during the fiscal year ending June 30, 1892:

There was no work of construction in operation at Sioux City during the year.

A shore-line survey of the river from Milwaukee Point to the Railroad Bridge was

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made in November. The notes were platted in the office at Omaha during the latter part of February.

On February 25 levels were run over the bar in front of Sioux City on the dike lines. The elevations thus obtained were afterwards platted and compared with levels run over the same lines on June 20, 1890, and also with the original cross sections made in April, 1889, just previous to the construction of the dikes. The result of the comparison is shown by the accompanying cross sections. (Plate II.)

The total amount of material deposited since April, 1889, between the original Iowa shore line and the outer ends of the several dikes, and between dikes Nos. 1 and 9, is approximately 501,000 cubic yards.

An examination of the river was made on June 7, and the dikes were all found to be in an unimpaired condition. The bar caused by the dikes is continually increasing in area as well as in elevation.

During the past year the channel has followed the left shore line from Milwaukee Point to within about 3,500 feet of Dike No. 1, there making a crossing and striking hard against the lower end of the Pacific Short Line Railway revetment at an angle of about 50°.

The cutting of the right bank in the vicinity of Covington has been continuous throughout the year. The maximum normal cut from November to June 7 was 275 feet. (See Plate I.)

On May 18 a flood in the Floyd River caused the western portion of Sioux City to be inundated, and for several hours water was flowing into the Missouri River over the entire distance from Dike No. 4 to the railway bridge, and resulted in breaking and washing down the top of the heretofore perpendicular bank between the two places.

In compliance with instructions received on May 13, a temporary gauge was established at the mouth of Perry Creek, and an observer employed to take and report readings.

The stage of water during the year, as shown by the standard gauge readings, ranged between an elevation of 666′.15 on December 9 and 675′.70 on June 10.

The accompanying maps and illustrations are described as follows:

First. Plate I, consisting of a map of the Missouri River in the vicinity of Sioux City from Milwaukee Point to the Chicago, St. Paul, Minneapolis and Omaha Railway Bridge; date of survey being November, and stage of river, Sioux City gauge, 667′.50.

Second. Plate II, representing nine cross sections taken on the dike lines of the Sioux City bar, showing total deposit since the dikes were constructed. Date of levels, February 25.

Third. Photograph taken from Prospect Hill looking west, showing the dikes and their effects in way of bar formation. Date of view, December 1, and stage of river, Sioux City gauge, 666′.80.

FINANCIAL STATEMENT.

Cost of surveys	$110.95
Cost of repairs to plant at Council Bluffs boat yard	5,274.95
Total	5,385.90

I am, very respectfully, your obedient servant,

CHAS. F. POTTER,
Division Engineer.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

APPENDIX B 1.

MISSOURI RIVER COMMISSION,
OFFICE OF DIVISION ENGINEER,
Omaha, Nebr., June 25, 1892.

COLONEL: I have the honor to submit the following report of operations under my charge in connection with improving the Missouri River in the vicinity of Council Bluffs, Iowa, during the fiscal year ending June 30, 1892:

The work consisted in revetting 9,220 linear feet of the left bank of the Missouri

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River in the vicinity of Council Bluffs, Iowa, the protection thus made practically becoming a continuation of the revetment constructed during May and June, 1890, and of similar make.

The work of procuring construction material was begun the latter part of July, but, owing to high water, actual work on revetment was not commenced until near the close of August. The revetment was started at A (see accompanying map), the terminus of the 1890 work, and extended down the left bank to B, a distance of 3,219 feet. On the reach B to C, a distance of about 2,800 feet, the work of protection was omitted, it being considered unnecessary owing to the unusually great resistance of the bank against erosion.

A comparison of the surveys made in 1879 and 1890 showed no perceptible change in the shore line between B and C, although the channel of the river followed that shore during the intervening time.

The revetment from C to F was built continuous, with the exception of a space D to E, 418 feet in length, extending above and below a gumbo point.

This projection was found to act as a dyke, with detrimental effect to the régime of the river, and consequently was left unprotected in anticipation of future erosions sufficient to wear it away and produce the desired shore line.

The manner of obtaining material and the method in which the revetment was constructed will be described under the several heads, as follows:

Cutting brush.—About 92 per cent of all the willow brush used was purchased standing in the field, and was cut, bound with wire, hauled to accessible landings, and loaded on barges by day labor.

The remaining 8 per cent was purchased delivered on the bank of the river, and thus the necessary labor was confined to loading the barges.

A brush-cutting party was organized on July 20, and, with an exception of eleven days in September, the force was employed continually until October 19. A second brush party was placed in the field August 10 and disbanded August 31. Measurement of the brush taken immediately after the barges were loaded was used in settlement for purchases made.

Most of the brush was obtained in the vicinity of Plattsmouth, Nebr., although a few barges were loaded near the mouth of Boyer Creek. All barges were loaded to carry from 175 to 225 cords of brush each, and, owing to the increase in density caused by thus heavily loading the barges, it is estimated that a gain of 20 per cent in the actual amount of brush was made over the measurement of previous years, when the barges were loaded to carry only 100 cords. The total amount of brush used during the season was 3,448 cords; and the average cost per cord, after being loaded on barges, was $1.956. It was found necessary to haul some of the brush 3 and 4 miles by teams, and in consequence the average cost of the brush was about 30 cents per cord greater than it was in 1890, when the distance of haul was less.

Sinking piles.—Oak anchor piles, varying in length from 20 to 25 feet, were sunk 10 feet apart along the bank at the water's edge. Nine hundred and sixty piles were sunk, and the average penetration was 18¼ feet. The average cost of sinking each pile (exclusive of cost of material) was $1.186+, and the cost per foot of penetration was 6.6 cents.

The piles were purchased of S. P. McConnell, of Council Bluffs, Iowa, and were delivered at the boatyard for 15 cents per linear foot.

Mattress.—Mattress work was commenced on September 1 and finished October 25. From September 8 to October 20 a second mattress party was employed. The mattress was woven 1 foot thick and to an average width of 69¼ feet, and was strengthened with the usual longitudinal and tranverse ⅜-inch galvanized cables running through the mattress 10 feet apart. A ½-inch galvanized cable was used on the outside selvage edge.

Grading bank.—The work of grading bank to a slope of 3 on 1 was done by using hydraulic graders Nos. 1 and 2, and the time occupied was from September 7 to October 31. A large portion of the material in the bank was hard gumbo, and the progress of the work was necessarily slow. The approximate amount of earth moved by the graders during the season was 45,775 cubic yards, and the average cost per cubic yard was 4¼ cents.

Rocking bank.—The rock used was a limestone, quarried at Weeping Water, Nebr., and furnished on barges at Omaha by Van Court and Lemist for $1.1475 per cubic yard.

The required number of barges were loaded daily from September 9 to November 15. A rigid inspection as to the manner of loading resulted in obtaining 2,862 pounds per cubic yard as the average weight during the season.

The upper bank was rocked to a depth of 1 foot from the line of anchor piles to the standard high-water line on the slope, the average width being 27 feet.

Sinking mattress.—The mattress was sunk to the bottom of the river by the use of

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about one-half cubic yard of rock per linear foot or 21 pounds per square foot of mattress.

Anchor cables.—The anchor piles were connected by ⅝-inch cables to deadmen sunk from the top of the high bank. The deadmen used were oak sticks, 6 to 8 inches in diameter and about 3½ feet in length.

Towing.—The brush and rock used during the season were transported by the use of the steamer *Capitola Butt*, she having been chartered for the work at a compensation of $20 per day.

During the first part of July the towboat was sent to St. Joseph, Mo., from which place she returned to Omaha with two hydraulic graders in tow. The total distance traveled by the towboat during the season of 137 days was 2,940 miles, and her average daily running expense, exclusive of the charter, was $33.01.

Repairing and launching plant.—The work upon repairs to plant which was begun the latter part of the fiscal year ending June 30, 1891, was continued to October 1. The hulls of pile-sinkers Nos. 3 and 4 and of the accompanying umbrella boats were wholly rebuilt above the water line.

All portions of quarter boats Nos. 2 and 4 below the second lower web strake were replaced by new material.

Extensive repairs were made to three 64-foot barges and to nine 100-foot barges. As the cost of repairs considerably exceeded the estimate, only such temporary repairs were made to the remainder of the boats as were thought necessary to warrant them standing the work for one season. Each boat was launched as soon as it was repaired and calked.

Pulling out boats.—Work of pulling out the boats on to the storage ways was commenced October 26 and was completed November 27.

Ice formed a gorge in the river on November 18, and eight boats were caught therein; but fortunately they were, with one exception, near the boatyard, and by the aid of the towboat the ice was broken about them sufficiently to admit of their being moved to the ways, where they were afterward pulled out.

The survey quarter boat was being used by a party at the time of the gorge, and was caught in the ice near the Northwestern Dikes. False ways were constructed, and the boat was pulled out at that place.

Care of plant.—On December 1 the boats and other engineer property were placed in charge of four watchmen, which number was reduced to three on April 15. On April 7 the survey quarter boat was launched from its winter quarters at the Northwestern Dikes and towed to the boatyard, where it has since been used for the accommodation of the watchmen. There being no construction work in operation, the remainder of the plant was left on the storage ways.

Surveys.—During the month of November a survey was made of the river from the mouth of Boyer Creek to the Union Pacific Railway Bridge. The computed distance between secondary triangulation stations Crescent and Flagstaff was taken as a base line.

The shore lines of the Iowa and Florence lakes were located, and ties made to street corners at Florence, Council Bluffs, and Omaha. The notes were platted at the Omaha office during the month of January. A portion of the map was used to accompany a report submitted February 13 relative to any probable danger which might exist of a cut-off taking place through Florence Lake and East Omaha.

In order to note the rapid changes due to erosion, the right shore line of the river in the vicinity of Florence Lake was surveyed on May 23 and again on the 31st.

The position of the shore line at the time of the last survey is shown on the accompanying map.

Cutting banks.—The most radical change due to erosion occurring on the Omaha reach during the year was in the right bank, in the vicinity of Florence Lake, where the cutting after April 1 was both constant and rapid. The maximum normal cut between X and Y (see accompanying map) from November to May 31 was 600 feet, and the area of ground washed away between the two points amounted to 47 acres.

Water flowed back and forth between the river and the lake during May and June, and the direction of flow changed as the elevation of the stage of the river was above or below 557 feet, Omaha gauge. Considerable cutting has taken place in the left bank from the mouth of Boyer Creek down to the point opposite to Florence, the estimated average normal cut being about 200 feet since November.

Condition of revetment.—The unexpected rise in the river which took place in May, together with the usual April and June rises, have given the revetment a severe test. An examination of the entire Council Bluffs revetment was made on June 25, and while the stage of the river was too high to note its exact condition, yet it was apparent that no serious damage had occurred.

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FINANCIAL STATEMENT.

Distribution of expenditure incurred in constructing 9,220 linear feet of revetment.

Sinking piles:			
Material (19,940 linear feet)		$2,942.60	
Fuel (87,585 pounds coal)		127.00	
Labor		732.95	
Subsistence		215.25	
			$4,017.80
Mattress construction:			
Material: Brush loaded on barges—			
Willows (3,448 cords)	$833.50		
Binding wire (9,990 pounds)	319.68		
Labor	4,186.33		
Subsistence	1,406.74		
		6,746.25	
Cable (11,000 feet $\frac{3}{4}$-inch and 100,615 feet $\frac{5}{8}$-inch)		1,722.87	
Labor		3,301.64	
Subsistence		1,349.70	
			13,120.46
Grading bank:			
Machinery supplies		58.34	
Fuel (333,790 pounds coal)		484.00	
Labor		1,199.43	
Subsistence		327.52	
			2,069.29
Rocking bank:			
Rock (9,220 cubic yards)		10,579.95	
Labor		2,382.45	
Subsistence		944.13	
			13,906.53
Sinking mattress:			
Rock (4,707 cubic yards)		5,401.28	
Labor		368.00	
Subsistence		139.50	
			5,908.78
Sinking deadmen:			
Labor		230.00	
Subsistence		86.60	
			316.60
Laying anchor cables:			
Cables (52,358 feet $\frac{5}{8}$-inch)		625.32	
Staples (906 $\frac{5}{8}$-inch)		27.00	
Labor		69.00	
Subsistence		26.00	
			747.32
Sawing off tops of piles:			
Labor		69.00	
Subsistence		26.00	
			95.00
Towing:			
Charter (137 days)		2,740.00	
Machinery supplies		71.35	
Fuel (942,895 pounds coal)		1,367.20	
Labor		2,490.15	
Subsistence		594.24	
			7,262.94
Repairing, launching, and care of plant:			
Material		2,676.61	
Labor		10,131.42	
Subsistence		2,360.20	
			15,168.23
General supplies			1,987.61
Sundry expenses: (office and telephone rent, traveling expenses, stationery, etc.)			796.20
Pulling out boats:			
Labor		$1,005.49	
Supplies		25.35	
Subsistence		284.55	
			1,315.39

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Surveys:		
Labor	$318.90	
Subsistence	42.40	
		$361.30
Administration:		
Labor	6,015.22	
Subsistence	100.14	
		6,115.36
Total		73,188.81

The above expenditure was charged as follows:

Sioux City allotment	5,274.95
Council Bluffs allotment	67,913.86
Total	73,188.81

COST OF 9,220 LINEAR FEET OF REVETMENT.

Exhibit showing cost per linear foot of each branch of the work; also the ratio of cost of each item to total cost.

Classification.	Cost per linear foot.	Per cent of total cost.	Classification.	Cost per linear foot.	Per cent of total cost.
Sinking piles	$0.4358	5.49	Repairing, launching, and care of plant	$1.6451	20.73
Mattress construction	1.4230	17.93	General supplies	.2156	2.71
Grading bank	.2244	2.83	Sundry expenses	.0864	1.09
Rocking bank	1.5083	19.00	Pulling out boats	.1427	1.80
Sinking mattress	.6409	8.07	Survey	.0392	.49
Sinking deadmen	.0343	.43	Administration	.6632	8.36
Laying anchor cables	.0811	1.02			
Sawing off tops of piles	.0103	.13			
Towing	.7877	9.92	Total	7.9380	100.00

The map and photographs accompanying this report are described as follows:

First. Map of the Missouri River from mouth of Boyer Creek to Union Pacific Railway Bridge. Surveyed November, 1891.

Second. Photograph showing Council Bluffs revetment. View taken from Gumbo Point looking down stream.

Third. Photograph showing Council Bluffs revetment. View taken from a point one-half mile above boat-yard, looking down stream.

I wish to acknowledge the valuable assistance rendered by Assistant Ed. Jones, who was in immediate charge of the work of construction.

I am, colonel, very respectfully, your obedient servant,

CHAS. F. POTTER,
Division Engineer.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

APPENDIX C.

ANNUAL REPORT OF MR. S. WATERS FOX, DIVISION ENGINEER, 1892.

MISSOURI RIVER COMMISSION,
OFFICE OF DIVISION ENGINEER,
St. Joseph, Mo., June 30, 1892.

COLONEL: I have the honor to submit herewith a report of the operations under my charge on the St. Joseph division of the Missouri River during the fiscal year ending June 30, 1892. The following maps and photographs accompany the report, viz:

First. Two photographic views of construction work in Belmont Bend.

Second. Map (tracing) of St. Joseph Reach, showing location and progress of improvement works as well as changes in shore lines.

Third. Sketch map (tracing) of Atchison Reach, showing the new shore alignment at the Doniphan cut-off.

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IN THE VICINITY OF NEBRASKA CITY, NEBRASKA.

The general repairs to plant, begun during the previous fiscal year, were continued until August 14, at which time all the wooden hulls had been repaired and launched.

The new boiler for the steamer *Sabrina* was not received until August 10; the necessary alterations and repairs were begun August 15. Besides some changes inside the hull, the forward skylight was lengthened to take in the chimney casing, and the entire roof aft of the wheelhouse was raised to the level of the roof of the old skylight; the port wheel flanges were reforged, bushed, and shrunk on the shaft; the pedestals were reënforced with chains to prevent a rocking movement of the engine frames. September 7, these repairs, although not finished, were sufficiently advanced for service; and as the steamer was urgently needed on the work she was put in commission on that day and left for St. Joseph with a tow, consisting of one rock barge, one mattress boat, and one small barge, the latter being loaded with coal.

As no further work was contemplated at Nebraska City during the season, the storage and launching ways with their supports were taken up and loaded on barges for transportation with the entire plant to St. Joseph. On September 11 the office there was closed, and Assistant Joseph C. Meredith, who had been in local charge of the work, was assigned a position in the field on the St. Joseph Reach. The few hulls there at that time awaiting transportation to St. Joseph Reach were left in care of two watchmen. The last of these was taken in tow by the *Sabrina* September 27, and the watchmen were discharged.

Cost exhibit of repairs to and launching of hulls at Nebraska City, Nebr., from July 1, 1891, to June 30, 1892.

Labor.	Work done.	Amount.	Total.
Administration	Office and clerical work	$505.00	
Care of plant	Watching boats and other property	224.50	
			$729.50
Carpentering	Repairs proper	1,456.37½	
Calking		784.97½	
Blacksmithing		2.00	
Labor		265.90	
Machinist		9.80	
Teaming		30.35	
			2,549.40
Repairs to Sabrina			843.08
Launching boats			252.29
Removing boatways			428.65
Total all classes			4,802.92
Material:			
Plant material	Lumber, oakum, iron, etc	680.69	
Plant purchased	Boiler and fixtures, and tools	869.50	
Supplies	Oil, paint, and tallow	92.34	
			1,642.53
Total expenditures			6,445.45

List of pieces repaired and launched.

6 barges, 25 by 100 feet.
2 quarter boats, Nos. 1 and 5.
1 hydraulic grader, No. 5.
1 mattress boat.
1 steamer, *Sabrina*.

A reconnoissance of the reach was made June 8, 1892. The island revetment was intact throughout its entire length.

The river in Copelands Bend has not changed materially; its flow on that date was concentrated against the bluff near the lower end of the bend; from that point a crossing was made to Nebraska City Island, the current impinging on the revetment at a point about midway between its upper and lower extremities. For a distance of about 500 feet from its upper end the revetment is in dead water, while a shore bar partially submerged at that stage makes out for quite a distance.

At lower stages the river has evidently hugged the right bank, making a false point at the lower end of Copelands; and under this action the shore line from the point to the bridge has receded, until now it is very close to the bluff all the way.

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IN THE VICINITY OF RULO, NEBRASKA.

No work was done during the year in the vicinity of Rulo. A reconnoissance of the reach was made June 10, 1892. No change of great importance has occured.

A shore bar has formed against the revetment and extends from its head over half the length of the work. The shore line of the bend below the revetment has receded considerably.

IN THE VICINITY OF ST. JOSEPH, MISSOURI.

Operations on the St. Joseph Reach consisted in revetment construction and repairs in Belmont and Bon Ton bends, dike repairs, the construction of new launching and storage ways, the care and repair of plant, surveys, and miscellaneous work incident thereto.

Belmont Bend revetment.—The ballasting of that portion of the revetment which had been constructed in June, 1891, at the head of Belmont Bend (746 linear feet) was finished July 10. Six hundred and eighteen cubic yards of riprap stone were thus expended, making the total quantity of rock on that piece of mattress 1,104.09 cubic yards.

Work was then suspended, as the stage of water was too high for the proper construction of revetment.

In accordance with the instructions contained in your letter dated July 8, 1891, the method of revetment construction employed on the St. Joseph division during the year has conformed, except in details, to that followed on the other divisions.

August 20, pile-sinker No. 7 was put in service sinking anchorage piles with a jet, in advance of the mattress. After a week's trial this method was abandoned on account of the sloughing of the bank that occurred sooner or later, causing the disarrangement, if not entire loss, of the work done. Pile-sinker No. 13 was put in service August 26, driving anchorage piles with an 800-pound hammer, and, proving to be much more efficient and satisfactory, was, with some slight interruptions, kept in service until October 10, when the last pile was driven. Eight hundred and fifty piles were driven to an average penetration of 15 feet in two hundred and four hours, at a cost of $0.9185 per pile.

Weaving mattress was begun, with one party, August 22; two other parties were put in service August 26, and a fourth party September 18. One party was laid off September 30, the second and third on October 6 and 9, respectively, and the last one finished work October 10, having lapped well on the old Elwood revetment. The total mattress woven was 14,877½ linear feet, or 1,096,347 square feet, protecting 14,246 linear feet of bank. The brush parties finished work and were disbanded October 8.

Bank grading was begun September 3, and finished October 30. Hydraulic pile-sinker No. 7 was in service, as a grader, 39 working days; hydraulic graders Nos. 6 and 7 were in service 44 days and 33 days, respectively. Fifteen thousand seven hundred and forty-five linear feet of bank, containing 100,744 cubic yards of earth, were graded, at a cost of $0.0213 per cubic yard.

The ballasting of the mattress began September 1 and continued, without serious interruption, until November 17, when ice began running in the river; from that time until December 9, when work in the quarry was suspended, little progress was made. The quarry was reopened March 2, 1892. April 2, the work of ballasting the upper bank of Belmont revetment was resumed and continued during that month, when, for want of funds, work was suspended. This leaves a strip 4,000 feet long where the rock lacks about 2 feet of being up to S. H. W.; 750 cubic yards will be required to finish it.

The total quantity of riprap stone placed on the revetment is 28,016.73 cubic yards. The location of the revetment is shown on the accompanying map (F to G). The length of the revetment provided for in the estimate, and upon which the allotment of funds was made, was 13,000 feet.

A hydrographic survey of Belmont Bend was made December 7–31. One hundred and forty-four partial cross sections, on ranges normal to the revetted shore line and 100 feet apart, beginning at the upper end of the revetment, were very carefully and accurately sounded. The soundings were made 10 feet apart with gas pipe, from a barge. Each sounding was located, and accurately referred to St. Louis City Directrix. In this way the position of the mattress throughout its length and width was closely determined.

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Cost exhibit in detail of 14,246 linear feet of revetment at Belmont Bend.

Classification and extent.	Cost per unit.	Cost each item.	Cost per linear foot.	Total cost.
Procuring 6,819 cords of brush, viz:				
Stumpage, 6,819 cords	$0.0608	$414.59		
Cutting	.3098	2,015.88		
Binding:				
Labor $943.97				
Material 216.15				
	.1261	1,160.12		
Loading wagons	.0989	674.75		
Hauling	.3015	2,056.82		
Barging 4,713 cords	.2591	1,221.31		
Subsistence	.1861	1,269.82		
Towage:				
Labor	.0641	302.17		
Fuel	.0278	131.22		
Subsistence	.0291	137.47		
	....	9,383.15	$0.6586	$9,383.15
Procuring 28,016.73 cubic yards of rock, viz:				
Quarry privilege, 27,974.73	.0150	419.62		
27 cubic yards free	....	....		
Stripping	.1992	5,582.84		
Cleaning quarry	.0002	79.70		
Quarrying	.2172	6,086.43		
Loading wagons	.0650	1,821.99		
Constructing rock road and pier	.0106	299.79		
Hauling to the work 3,508.70 cubic yards	.1795	629.90		
Hauling to the barges 24,508.03 cubic yards	.1794	4,397.14		
Loading barges	.0608	1,490.49		
Supplies	.0273	766.94		
Subsistence	.0685	1,919.90		
Towage:				
Labor	.0423	1,038.61		
Fuel	.0310	759.98		
Subsistence	.0083	203.64		
	....	25,496.97	1.7900	25,496.97
Weaving 14,877½ linear feet mattress, viz:				
Labor	.4400	6,546.86		
Subsistence	.1827	2,719.22		
	.6227	9,266.08	.6503	9,266.08
Anchoring 14,877½ linear feet mattress, viz:				
Labor	.1260	1,825.12		
Subsistence	.0250	372.53		
Strand, ⅝-inch, 94,346 pounds, at 4½ cents	.2853	4,245.57		
Cable, 1¼-inch, 128,720 pounds, at ¾ cents	.0648	965.40		
	.5011	7,408.62	.5200	7,408.62
Hydraulic grading, 100,744 cubic yards, viz:				
Labor	.0136	1,380.05		
Fuel	.0041	420.00		
Supplies	.0005	52.17		
Subsistence	.0029	301.87		
	.0211	2,154.09	.1512	2,154.09
Grading by hand, labor	....	72.77	.0051	72.77
Driving anchor piling, viz:				
Labor	.6559	557.59		
Fuel	.0809	68.79		
Subsistence	.1816	154.41		
Material, 850 piles	.1003	852.54		
	1.0187	1,633.33	.1146	1,633.33
Placing 28,016.73 cubic yards of rock, viz:				
Labor	.1236	3,463.00		
Subsistence	.0621	1,741.20		
	.1857	5,204.20	.3653	5,204.20
Total	....	....	4.2551	60,619.21

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Bill of cost of 14,246 linear feet of revetment at Belmont Bend, 1891-'92.

Classification and extent:	
6,819 cords of brush, stumpage, at $0.0608 per cord	$414.59
4,713 cords of brush, on barge at the work, at $1.7359 per cord	8,181.55
5,781 pounds binding wire, at $0.0374 per pound	216.15
94,346 pounds wire strand, ⅜-inch, at $0.045 per pound	4,245.57
128,720 pounds cable, 1¼-inch at $0.0075 per pound	965.40
850 cottonwood piles, at $1.002 per pile	852.54
28,016.73 cubic yards of rock, viz:	
Quarry privilege	419.62
Quarry supplies, powder, fuse, etc	766.94
28,016.73 cubic yards of rock procured by hired labor	22,308.18
Labor and subsistence, viz:	
Ballasting	5,204.20
Weaving	9,266.08
Anchorage	2,197.65
Labor, fuel and subsistence, viz:	
Hydraulic grading	2,226.86
Sinking and driving anchor piling	780.79
Towage	2,573.09
Total cost, exclusive of administration, care, and repair of plant	60,619.21

Miscellaneous data and elements of cost exhibit, Belmont Bend, 1891-'92.

Classification and extent:		
Linear feet of mattress		14,877½
Square feet of mattress		1,096,347
Total cost		$60,619.21
Cost per linear foot of mattress		$4.0745
Cost per linear foot of revetment		$4.2551
Cost per square (100 square feet)		$5.52
Meals issued to work (number)		24,081
Subsistence, cost per capita per diem:		
Labor	$0.0936	
Stores	0.2904	
		$0.3840

About the middle of April, 1892, a break in the Elwood revetment (constructed 1883) occurred just below the end of the new Belmont revetment. This resulted from eddy action due to the abrupt change in the shore alignment. For two weeks or more the break enlarged very little, and, as the wearing away of the point tended to ameliorate the conditions of flow there and to insure greater ability on the reach below, the only cause for apprehension seemed to lie in the fact that there was no money available for use in holding the shore line when it should have receded as far as desired. During the month of May, however, the river rose steadily until the 20th, when it had attained an elevation of 1.2 feet below S. H. W. As the river rose the force of the eddy increased and the pocket formed by it enlarged very rapidly. Subsequently there has been very little change in shore lines. On the 16th of May, when the stage of water was about 3 feet below S. H. W., a violent windstorm from the northwest piled the water up in the lower end of Belmont Bend until the upper bank protection was submerged and the bare bank exposed to wave action. This resulted in benching the upper bank back in places nearly to the top of the grade over a length of bank about 2,000 feet. In order that the matter might be clearly presented to you some photographic views of the bank were taken May 25 and submitted at a consultation on the 27th. Acting upon this information you instructed me in case a transfer of requisite funds ($2,500) could be effected to regrade that part of the upper bank which had been washed out and to cover it with rock ballast to an elevation 3 feet above S. H. W.; also to construct a mattress across the large pocket formed by the eddy, lapping well the old work, the inner edge of the mattress to be held in place by two rows of piles, the latter to be well braced and hurdled. Such preliminary arrangements for carrying out these instructions as seemed justified, in advance of the information that the transfer of funds had been effected, were made with a view to finish the work before the June rise.

Pending the transfer, notice of which was received June 9, changes in the conditions occurred, making a change in the plans necessary, viz: June 7, soundings were made with a view of determining the position of the mattress; when compared with the position as determined by the survey made in December, 1891, referred to above, they showed that, from section 132 to 138, the mattress had settled by scour from 8 to 16 feet along its inner edge, and from 23 feet to 32 feet along the outside. These facts were presented to you June 10, and, in accordance with your instructions, a project for the expenditure of the funds available (2,500) was prepared and

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submitted under date of June 14. This project, which was approved June 15, provides for the construction of a series of short permeable spur dikes, one on each of the section range lines beginning at range 131-132. The dikes to be built of two rows of piles extending from the bank out at least two bents beyond the inner edge of the mattress; the tops of the dikes to be given an elevation at their outer ends two feet below S. H. W., and at their shore ends three feet above S. H. W.; each dike to be provided with a foot mattress 25 feet wide; into the foot mat a vertical screen mattress, from 3 to 8 feet high, is to be woven on the upstream side of the lower row of piles; the poles forming the curtains to be introduced into the vertical mattress. The piles to be spaced 11 feet between centers in the row, and the rows spaced apart 13 feet between centers; there are to be two strings of wales on the upper sides of the dikes, and one on the lower side; the upper dike will be cross braced horizontally for its entire length; the others will be cross braced for three bents from their outer ends. The piles, wales, and braces to be taken from the supply on hand and stored at Winthrop, Mo. The project also provides for the construction of a two-row pile dike, of similar design, at or near the middle ordinate of the big eddy. (See accompanying map g.)

The bank from section 122 to section 132, or that portion where the damage was confined to the benching back of the upper bank, was regraded, where necessary, after having first faired out the pockets with brush. All of the cables and strand whose deadmen were in danger of being washed into the river were extended and given new anchorage.

All of the materials and plant necessary for the dike work were gotten on the ground by the 25th instant. The construction of foot mattress was begun the 20th and pile-driving on the 22d.

By June 30 Dikes Nos 1, 2, 3, and 4 had been finished. On No. 5, the foot mattress had been made and partially rocked; four bents of piles had been driven and braced. On No. 6, 1,650 square feet of foot mattress had been woven.

The total cost of the above work, to June 30, 1892, was $2,079.05.

Bon Ton revetment repairs.—In the latter part of June, 1891, two breaks occurred in the upper bank protection in Bon Ton Bend, distant about 2,700 feet below the head of the revetment. Inspection showed that these were surface cuts only, and that the low-water mattress was intact. The cables and strand whose deadmen were in danger of being washed in were extended and given new anchorage.

An attempt was made to hold the bank at the breaks by the use of riprap, but the river continued to rise until it was bank-full at that point, and it was finally thought best to wait until it receded, and then put in a patch. Under date of July 18, 1891, I submitted to you a special report on the conditions of flow that then prevailed on the several reaches of the St. Joseph division of the river, as well as the conditions of the various works of improvement thereon. As was noted therein, the breaks in the Bon Ton revetment at that time extended over 2,500 feet of bank, and were nearly, though not entirely, continuous from a point about 500 feet below the lower end of the revetment constructed in the fall of 1890. The entire length involved in the breaks is on low ground, with a levee back of the bank, and was revetted under very unfavorable circumstances during the high water of 1885. It was proposed to repair the break by a new revetment, constructed in accordance with the instructions contained in your letter of July 8, 1891. The estimates for this work submitted August 4, 1891, provided for the construction of 3,000 linear feet of revetment, at a cost of $12,420, the work to begin at the lower end of the revetment put in during the fall of 1890. This, in addition to a proposed expenditure of $3,870 for dike work, aggregated an amount $7,968.27 in excess of the balance available at that time for field work. This excess was provided for by the transfer of $8,000, notice of which was received under date of August 18, 1891.

Active operations began with the sinking of anchorage piles July 31. A jet was first used, but was subsequently abandoned, owing to the difficulty of penetrating the old mattress, as well as on account of sloughing caused by the jet where the old mat was not encountered. The work thereafter was done satisfactorily with a light hammer (800 pounds), the driver following the mattress boats. One hundred and ninety-one piles were driven to an average penetration of 15 feet in 48 hours, at a cost of $1.2612 per pile.

Weaving mattress began August 3, with one party; two other parties were put in service August 4 and 11, respectively. By August 20, when the weaving was finished, 3,018 linear feet or 218,976 square feet of mattress had been made, covering 3,000 linear feet of bank.

Pile-sinker No. 7, fitted up as a hydraulic grader, began grading the upper bank August 5, and finished work August 19. Sinker No. 13 was in service as a hydraulic grader, also, from the 10th to the 17th of August. Three thousand three hundred and seventeen linear feet of bank containing 15,068 cubic yards were graded at a cost of 2.23 cents per cubic yard. The brush used on this work, 1,320 cords, was procured by hired labor, at a cost of $1.6767 per cord, delivered on barges at the points of expenditure. The rock ballast was obtained, by hired labor, from the

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quarry at Belmont, Kans., with the exception of 662.5 cubic yards which were taken from the old revetment in Bon Ton Bend above S. H. W.; 6,055.77 cubic yards, in all, were expended in ballasting, of which 4,033.27 cubic yards were placed before the general suspension of field work last winter, and the balance in the spring; this quantity being just sufficient to reach the S. H. W. contour.

Cost exhibit in detail of 3,000 linear feet of revetment in Bon Ton Bend.

Classification and extent.		Cost per unit.	Cost each item.	Cost per linear foot.	Total cost.
Procuring 1,320 cords of brush, viz:					
Stumpage		$0.0608	$80.25		
Cutting		.1653	218.33		
Binding:					
Labor	$115.57				
Material	41.84	.1192	157.41		
Loading wagons		.0678	89.57		
Hauling		.3673	484.90		
Barging 1,141 cords		.2645	301.85		
Subsistence		.3229	426.29		
Towage:					
Labor		.2098	239.48		
Fuel		.0841	96.03		
Subsistence		.0168	19.20		
		....	2,113.31	$0.7044	$2,113.31
Procuring 5,393.27 cubic yards of rock, viz:					
Quarry privilege		.0150	80.90		
Stripping		.1993	1,075.27		
Cleaning quarry		.0002	15.85		
Quarrying		.2173	1,172.28		
Loading wagons		.0650	350.92		
Constructing rock road and pier		.0107	57.74		
Hauling		.1795	968.23		
Loading barges		.0608	328.22		
Supplies		.0274	147.87		
Subsistence		.0685	369.78		
Towage:					
Labor		.0103	55.69		
Fuel		.0075	40.74		
Subsistence		.0072	39.16		
		....	4,702.15	1.5674	4,702.15
Weaving 3,018 linear feet of mattress, viz:					
Labor		.4628	1,396.95		
Subsistence		.2268	684.59		
		.6896	2,081.54	.6938	2,081.54
Anchoring 3,018 linear feet mattress, viz:					
Labor		.1238	373.90		
Subsistence		.0279	84.48		
Strand, ⅜-inch, 19,013 pounds, at 4½ cents		.2834	855.58		
Cable, 1¼ inches, 24,500 pounds, at ¾ cents		.0601	183.75		
		.4952	1,497.71	.4992	1,497.71
Hydraulic grading, 15,068 cubic yards, viz:					
Labor		.0153	230.18		
Fuel		.0037	56.64		
Subsistence		.0033	50.17		
		.0223	336.99	.1123	336.99
Sinking and driving anchor piling, viz:					
Labor		.8735	166.84		
Fuel		.2087	39.88		
Subsistence		.1789	34.17		
Material, 191 piles		.9503	181.52		
		2.2114	422.41	.1408	422.41
Placing 5,393.27 cubic yards of rock, viz:					
Labor		.1553	837.85		
Subsistence		.0250	135.21		
		.1803	973.06	.3244	973.06
Total		....	....	4.0423	12,127.17

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Bill of cost of 3,000 linear feet of revetment in Bon Ton Bend, 1891-'92.

Classification and extent:	
1,320 cords of brush, stumpage, at $0.0608 per cord	$80.25
1,141 cords of brush, on barge at the work, at $1.4342 per cord	1,636.51
1,119 pounds binding wire, at $0.0374 per pound	41.84
19,013 pounds wire strand, ⅜ inch, at $0.045 per pound	855.58
24,500 pounds cable, 1¼-inch, at $0.0075 per pound	183.75
187 cottonwood piles, 18 feet long, at $0.90 per pile	168.30
4 cottonwood piles, 40 feet long, at $3.305 per pile	13.22
5,393.27 cubic yards of rock, viz:	
Quarry privilege	80.90
Quarry supplies, powder, fuse, etc	147.87
5,393.27 cubic yards of rock procured by hired labor	4,337.79
Labor and subsistence, viz:	
Ballasting	973.06
Weaving	2,081.54
Anchorage	458.38
Labor, fuel, and subsistence, viz:	
Hydraulic grading	336.99
Sinking and driving anchor piling	240.89
Towage	490.30
Total cost, exclusive of administration, care, and repair of plant	12,127.17

Miscellaneous data and elements of cost exhibit Bon Ton Bend, 1891-'92.

Classification and extent:		
Linear feet of mattress		3,018
Square feet of mattress		218,976
Total cost		$12,127.16
Cost per linear foot of mattress		4.0182
Cost per linear foot of revetment		4.0423
Cost per square (100 square feet)		5.5381
Meals issued to workmen (number)		11,392
Subsistence cost per capita per diem:		
Labor	$0.0936	
Stores	.2904	
		$0.3840

In December, 1891, the entire revetment in Bon Ton Bend was gone over, and those portions of the mattress which were bare were re-covered with rock taken from above S. H. W. contour. The cost of this work was $45.70.

In the latter part of April, 1892, and along through the months of May and June, from time to time, small breaks occurred in the upper-bank protection of the work just described. Two small breaks also occurred in the old revetment of 1885 a short distance below. With one exception they were surface cuts, due to combined forces of current and wave action. The exception referred to was in the first break that occurred. It was on the new work. Here, evidently, there was first a scour of from 5 to 10 feet underneath the mattress. Owing to the shape of the pocket in the shore line at that point the mattress was unable to follow promptly the scour, and meanwhile the flow underneath it caused the caving of the upper bank. Finally, however, the mattress settled down part way, the eddy broke, and the pocket was filled back, both underneath and on top of the mattress, to something like the normal section. This and the other breaks were repaired as soon as possible after they appeared by filling out with brush from the toe of the bank to the anchorage piles, regrading the bank, and covering with rock ballast to S. H. W.

In the latter part of May it became apparent that the small balance of funds then available for this work would not be sufficient. The sum of $500 was therefore asked for, to be expended in completing the repairs then in progress and as a provision against further damage to the work that might reasonably be anticipated.

Under date of June 8 notice was received that the transfer of funds had been effected; a project for its expenditure, in accordance with the above, was submitted June 14.

The repair of the last break which has occurred up to the close of the fiscal year was finished June 21, 1892. The total expenditure for these repairs up to date is $706.90.

Pile-dike extension and repairs.—During the June rise of 1891 the pile dikes on the

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upper reach (see accompanying map B C and D E) were damaged to some extent. The following repairs were made in July, viz:

Number of dike.	Number of piles sunk.	Linear feet of curtain.	Number of pieces, wales and braces.	Cubic yards of rock.	Remarks.
3	26	317	56	5	Lower system.
2	3			15	
4	25	90	71	125	Upper system.

It was intended that the extension of these dikes to their projected lengths should be made during the month of August; but at that time the Kansas Chute, in which they are located, was so silted up that the materials and fleet necessary for the work could not be gotten to them. Subsequently, however, the percentage of the low-water discharge carried by that chute increased until, in the latter part of October, 1891, it amounted to about 75 per cent. There was a tolerably good steamboat channel up as far as Dike No. 1 of the upper system; above that point the reach to Amazonia Cut-off was wide and flat, with no well-defined channel. Meanwhile both systems were threatened with flanking by erosion from above, and several bents close to the shore on Dike No. 4 had scoured out. This dike and No. 3 of the lower system were still short of their projected lengths, but the channel way at both places was too narrow to permit of full extensions. It was, therefore, thought best to make partial extensions with three rows of piles and reënforce the old work where exposed with a third row of piles on the lower side.

Work was begun November 2, 1891, and, after many interruptions, on account of storms and ice in the river, was finally suspended December 18.

One hundred and twenty-five piles were sunk, of which fifty-seven were in Dike No. 4 and the balance in Nos. 1 and 3 of the lower system. Eight thousand eight hundred and eighty-five square feet of foot mattress had been woven, of which 1,375 square feet were on Dike No. 4 and 7,510 square feet on Dike No. 1 of the lower system. The wales and braces had all been placed, but no foot mattress had been made on either No. 3 of the lower or No. 4 of the upper system. The materials needed were gotten to the dikes with the intention of making the mattresses at the first opportunity, but the new work on both of them went out before anything could be done.

In February, 1892, the following work was done on the dikes, viz:

Dike No. 1, upper system, square feet, mattress at shore end	2,958
Dike No. 1, upper system, linear feet, curtain placed	70
Dike No. 4, upper system, linear feet, curtain placed	270
Dike No. 1, lower system, linear feet, curtain placed	100
Dike No. 2, lower system (canted braces, 4 by 8 inches, 18 feet, bolted on)	18
Dike No. 3, lower system, linear feet, curtain and auxiliary anchorage (⅜-inch strand) placed	20

Bill of cost of repairs, reënforcement, and extension of dikes in the vicinity of St. Joseph, Mo.

Classification and extent:	
162 cords of brush, stumpage, at $0.0608 per cord	$9.85
162 cords of brush, at the work, at $0.2529 per cord	40.97
138 pounds binding wire, at $0.0374 per pound	5.16
835 pounds wire strand, ⅜-inch, at $0.045 per pound	37.78
24,233 feet, B. M., pine lumber, at $18.50 per M	448.31
1,252 bolts, at $0.077	96.44
145 cubic yards of rock on barge, at $0.8325 per cubic yard	120.72
179 piles, at $3.305	591.59
Labor viz:	
Weaving foot mat	194.62
Ballasting foot mat	29.07
Labor and subsistence, viz:	
Waling and bracing	321.56
Making curtain	128.49
Labor, fuel, and subsistence, viz:	
Sinking piles	953.12
Towage	319.11
Total	3,296.79

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It is difficult to say whether or not these dikes will finally accomplish the rectification of river desired. The conditions of flow on the reach above them are certainly not favorable. The active flow during flood stages is down the Missouri Chute; the Kansas Chute, being left with a sluggish current, if any, becomes choked with fine sand and mud. After the river has fallen to about a mid-stage or lower, it finds its way back into the Kansas Chute, and the flow of course, until the dikes come into action, is very erratic in alignment; then the first work to be effected by the dikes is the opening of a crossing through the deposits left by the flood, to the right bank of the island. By that time it is likely that the river will have fallen so low that there is little erosive power in its current; and, as winter sets in, this action becomes feebler and later on probably entirely averted by the erratic conditions that usually attend the appearance of ice in the river.

The accompanying map shows the extent of the erosion of the right bank of the island during the year, and those portions of the deposits made by the dikes which were above water at the time of the survey. A hydrographic survey could not be made, owing to the small amount of funds available.

Launching and storage ways.—The reconstruction of the ways in French Bottoms was necessitated by the demand for greater storage capacity, better facilities for repairing the fleet while on the ways, and convenience of arrangement with reference to putting into the water again any desired assortment of pieces, with minimum movement of other pieces.

The new yard was laid out on the site of the old one, increasing the area from 2 to 4.45 acres. The work of clearing the ground of timber and undergrowth, and removing the old ways and their supports was begun October 10, 1891. The new yard was finished November 30.

Two thousand and four piles were driven and 8,948 linear feet of ways placed. Of the latter, 6,804 feet were for storage proper, 1,512 feet in tracks, and 632 feet for launching. The surface of the storage ways is about 4½ feet above the general level of the ground in the yard. The total cost of the new yard was $3,599.62.

Bill of cost of reconstruction of launching and storage ways, French bottoms.

Classification and extent:	
749 cottonwood piles, at $0.6063 per pile	$454.18
11 cottonwood piles, at $1.002 per pile	11.02
9,598 feet, B. M., pine lumber, at $13.50 per M	129.57
3 kegs 30-penny wire nails, at $2.50 per keg	7.50
Labor, driving piles	601.40
Labor and subsistence, constructing boatways	2,308.45
Labor, fuel, and subsistence; towage	87.50
Total	3,599.62

Care, repair, and alterations of plant.—It was found necessary to provide additional quarters for the construction parties. A cabin was erected on one of the large barges similar in design to that constructed in June, 1891. The two cabins together afforded sleeping quarters for 264 men, and dining-room capacity for 375; they also provided storage room for subsistence stores and supplies for the entire field force, as well as a field office room.

They were equipped with an entire new set of kitchen and dining-room utensils. The cost of both cabins complete was $1,834.94; the cost of the equipment for both was $543.93.

The work of pulling the fleet out of the river began November 17, 1891, and was finished December 11; 44 hulls in all were pulled out and placed on the ways, viz: 17 rock barges, 11 brush barges, 5 quarter boats, 2 hydraulic dredgers, 2 hydraulic pile sinkers, 2 mattress boats, 2 umbrella boats, 1 tool boat, 2 steamers (*Thetis* and *Sabrina*). The cost of this work was $1,775.83.

The repair of those pieces that were to be used during the season on the St. Joseph Reach and those that were to be transferred to the first reach, was begun February 29, 1892, and finished March 17. The following pieces were repaired and launched, viz: 17 rock barges, 3 quarter boats, 1 mattress boat and tender, and the steamer *Sabrina*. Two hydraulic graders were side-tracked, to permit pieces behind them to be launched, and 2 quarter boats and 2 mattress boats were launched for the same reason. The six hulls were subsequently put back into place on their storage ways.

The repairs to the steamer *Sabrina* consisted in painting the entire boat inside and out; in covering the boiler and steam drum with asbestus cement, and completing the covering of her steam fittings with "I. X. L. steam covering." The new double-barreled steam capstan was placed in position and fitted up for use.

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Only such work was done on the other hulls as seemed necessary to make them serviceable for the season's work.

Cost exhibit of care, repair, and alterations of plant for the fiscal year ending June 30, 1892, at St. Joseph, Missouri.

Labor.	Work done.	Cost.	
Care of plant	Watching boats and other property		$3,039.93
Carpentering	Repairs proper, wooden hulls	$645.30	
Calking		627.98	
Blacksmithing		103.80	
Teaming		31.65	
Labor, unskilled		311.06	
			1,719.79
Repairs to *Sabrina*			365.68
Launching boats			1,409.86
Total labor, all classes			6,535.56
Material:			
Plant material	Lumber and oakum	96.87	
Plant purchased	Tools, capstans, sheaves, and cable	264.20	
Supplies	Oil, paint, and tallow	57.03	
			418.10
Total expenditures			6,953.36

The cost of repairing and launching barges for service on first reach, amounting to $1,345.91, is included in the above statement.

There were also the following items of repair work not included in the above, viz:

Repairing survey quarter boat	$86.87½
Launching survey quarter boat	6.12½
Repairing survey skiffs	3.75
Altering P. B. M. pipes	4.50
Total charged to survey allotment	101.25

Surveys and gauge inspection.—In addition to the hydrographic survey of the revetment in Belmont Bend (reported above), two hydrographic surveys of the upper reach, in the vicinity of the dikes, were made August 18 and September 30, 1891. A tracing of the map prepared from these surveys was submitted under date of October 10. Except some detached work incidental to construction operations, no other surveys were made during the year until June, when a partial shore-line survey of the reach was made, to show the changes that had occurred and the progress of improvement works made during the fiscal year. The cost of these surveys aggregated $348.35.

The regular monthly inspection of the gauges on the St. Joseph division were conducted from this office, as usual, until after the February inspection, when, in accordance with instructions from the secretary of the Commission, dated March 17, 1892, they were discontinued.

TOWBOAT SERVICE.

The towboat service during the year was performed by the U. S. S. *Alert*, *Sabrina*, and *Thetis*.

The *Alert* was in service from July 28 to October 2, at which time she was relieved, and cleared on the following day for Kansas City, with instructions to report there to Division Engineer Samuel H. Yonge. While under my orders she made two trips from St. Joseph to Nebraska City for floating plant; the balance of the time was spent on the St. Joseph Reach, towing rock and brush and in handling the working fleet.

The *Sabrina* was in service from September 7 to October 2 delivering floating plant from Nebraska City to St. Joseph. During that time four trips were made. She was then kept in service on the St. Joseph Reach doing all of the towing work required until December 12. She was in service again on the St. Joseph Reach from March 7, 1892, till April 21, at which time she was relieved, and cleared on the following day for the first reach, with instructions to report there to Division Engineer Samuel H. Yonge. The efficiency of the *Sabrina* as a towboat was greatly increased by the alterations and repairs previously noted. The new boiler generated easily all the steam at 160 pounds pressure that could be used. The following is a statement of the

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extent and cost of the work performed by her from September 7 to December 12, 1891, viz:

Days in service	95
Total miles run	3,068
Miles run light	1,248
Gross tons towed	63,425
Net tons towed	24,240
Gross ton-miles	346,758
Net ton-miles	119,584
Number hulls towed	490
Labor cost	$1,709.18
Subsistence cost (labor and stores)	399.00
Fuel and supplies cost	620.02
Cost per gross ton per mile	$0.00787
Cost per net ton per mile	.0228

The steamer *Thetis* was in service from July 1, 1891, to August 13, doing such general work as she was capable of.

IN THE VICINITY OF ATCHISON, KANSAS.

There was no construction work on the Atchison Reach during the year. A watchman was kept under pay at the rate of $20 per month to look after the United States property stored there, and to report any items of interest concerning the action of the river that might come under his observation. A shore line survey of the reach was made May 17 to 19, 1892. A tracing of the map prepared therefrom accompanies the report. The stage of water at the time was so high that it does not give one a very clear idea of the conditions of flow.

The cut-off between Rushville and McQueens Bend occurred June 29, 1891, at 4 o'clock a. m. As might be inferred from an inspection of the map, it was caused directly by overflow; the overflow found its way across the peninsula through low ground in two streams. The overpour of these two streams at the bank on the lower side of the peninsula caused a very rapid recession of the bank at those points, and this action continued until the cut-off was effected and the channel length of the river reduced 4.52 miles.

The middle channel way shown on the map was opened first, the peninsula being narrower and lower there than on the line of the southern or left hand channel way. The latter developed more slowly, but has for some time been the principal chute. At the time of the last survey there was probably 90 per cent of the discharge of the river passing through it. There was no appreciable flow through the "old river" around by Doniphan. It is probable that the middle chute will be silted up during this season to such an extent that it will carry none of the low-water discharge.

As will be seen on the map the line of principal flow, after leaving the cut-off, crosses over to the head of Atchison Island, impinging on the bank at a point some distance east of the head of the old chute that formerly separated Atchison Island from the main land. From the point of impact to where the current starts on its crossing to the left bank the shore line of the island is receding rapidly.

After striking the left bank, at a point about 2,000 feet above the system of dikes, the main floor is along by the ends of the dikes down as far as No. 19; a crossing is then effected to the right bank, high enough above the Chicago and Atchison bridge to afford an easy and safe passage through the west span of the draw.

The cut-off, changing entirely, as it did, the local régime of flow, subjected the improvement works below it not only to unusually violent forces, but changed the direction of flow beyond the limits that can be reasonably provided for in the location of improvement works. The result thus far has been that Dikes V, X, XIV, XVI, and XVIII have been shortened more or less; and that the new shore line which had been established by the dikes as projected and which up to this time had been maintained has receded somewhat. The revetment above the dikes, constructed by the railway companies in the winter of 1887–1888, stood the test without a break until April 14, 1892, when the upper bank work began to give way. Up to the present date there is one continuous break of about 1,000 feet, beginning at a point 500 feet above the uppermost dike and extending upstream (see accompanying tracing). The upper bank of perhaps one-half of the balance of the revetment has bluffed off to a greater or less extent; none of the deadmen, however, have gone in.

No new work is contemplated on this reach.

I am, colonel, with great respect, your obedient servant,

S. WATERS FOX,
Division Engineer.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

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APPENDIX D.

ANNUAL REPORT OF MR. SAMUEL H. YONGE, DIVISION ENGINEER, 1892.

MISSOURI RIVER COMMISSION,
OFFICE OF DIVISION ENGINEER,
Jefferson City, Mo., June 30, 1892.

COLONEL: I have the honor to submit my report of operations conducted in improving the Missouri River on Kansas City Division and First Reach during the fiscal year ending June 30, 1892.

REPAIR AND MAINTENANCE OF WORKS IN THE VICINITY OF KANSAS CITY, MISSOURI.

The operations carried on under the allotments made by the Commission for Kansas City consisted in completing the revetments at Little Platte Bend and Harlem, in repairing the Kaw Bend and East Bottoms revetments, in extending the Kansas City and Harlam Dikes, and in strengthening the dikes at Little Platte Bend.

Little Platte Bend Revetment.—The plant required for construction work at Little Platte Bend was towed there from Harlem, Mo., by the towboat *Alert*, July 9 and 10.

On account of the high stage of water, however, work could not be begun until July 23.

Its progress was interrupted by high water and stormy weather, on account of which it had to be temporarily suspended twice. The work consisted in protecting the 1,450 linear feet of bank situated above and adjacent to the revetment of 1889 by a revetment of the standard type.

The mattress was completed and the bank graded down to the water line by a hydraulic grader August 25, when the party and plant were moved to Kaw Bend by the *Melusina*.

Work was resumed October 8 and the bank grading finished by shovels, after which it was ballasted up to a stage of standard high water. The work was completed October 30.

The total length of revetment constructed at Little Platte Bend in 1887, 1889, and 1891 amounts to 7,770 feet; its cost, to $53,121.31, or $6.83 per linear foot. The following statement shows the details of cost and extent of the revetment constructed during the fiscal year of 1892:

Statement.

Class and extent of work.	Prices of materials.	Cost of each class of work.	Total.
Sinking 141 revetment piles:			
Labor and subsistence		$221.92	
3,666 linear feet cottonwood piling	$0.093	340.94	
75 pounds of 8-inch spikes	.0325	2.44	
225 bushels coal	.11453	25.77	
			$591.07
Weaving 103,420 square feet of mattress, = 1,485 linear feet, and anchoring mattress on top of bank:			
Labor and subsistence		1,085.53	
820 cords of brush	1.7398	1,426.64	
8,938 pounds ⅝-inch wire cable	.0447	399.53	
1,450 pounds ⅜-inch wire cable	.04	58.00	
496 ⅝-inch iron cable fastenings	.08	39.68	
238 ⅝-inch iron cable fastenings	.10	23.80	
			3,033.18
Ballasting 101,805 square feet of mattress below water:			
Labor and subsistence		118.14	
399 cubic yards of stone	.95405	380.67	
			498.81
Grading bank:			
Labor and subsistence, grading 1,120 linear feet = 2,013 cubic yards, with hydraulic grader		194.47	
140 bushels coal	.11453	16.03	
Labor and subsistence, grading 210 linear feet = 70 cubic yards, by shovels		14.52	
Trimming 1,440 linear feet of bank by shovels		55.13	
			280.15
Ballasting 66,006 square feet = 1,440 linear feet, of bank with stone:			
Labor and subsistence		585.85	
2,207 cubic yards of stone	.95405	2,105.59	
			2,691.44
Miscellaneous:			
Administration		72.47	
Incidental expenses		407.04	
Service of tow-boat Alert		95.00	
Service of steamer Melusina		495.76	
Care and repair of plant in service		316.24	
			1,386.51
Total			8,481.16

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Little Platte Bend dikes.—The four dikes constructed at the upper end of Little Platte Bend in 1889 were fully described in my report for that year. On account of the stream ends being gradually scoured out and undermined by the current, it became necessary, in order to preserve the dikes, to construct at the outer end of each of them a willow mattress apron. This work was done in August.

The aprons were about 100 feet long by 65 feet wide, and extended 40 feet beyond the outer bent of piles. The total area of mattress woven and sunk at the four dikes amounted to 24,070 square feet. Some slight repairs were also made to the bracing on some of the dikes.

The total cost of the work, including all labor, materials, steamboat service, etc., amounted to $1,309.

Repairs to Kaw Bend Revetment.—The length of revetment constructed in the lower part of Upper Kaw Bend in 1885 was about 10,000 feet.

About 2,000 feet of the work in the lower part of the bend had to have extensive repairs made to it in 1887 and 1889. Only slight repairs, however, were made on the remaining 8,000 feet. In the spring of 1891 it appeared, on examination, that the old mattress had pulled away from the bank at five places, forming breaks from 120 to 225 feet long. It was therefore thought advisable to risk the revetment through another period of high water without reconstructing parts of it and making general repairs to the entire work.

Repairs were commenced August 26. They consisted in driving anchor piles and constructing new sections of mattress at the toe of the bank, where the old mattress was broken at the water line; in removing the stone ballast; in regrading and reballasting the bank; and in filling up holes with brush. The mattress was made sufficiently wide to lap over the inner edge of the old one. Its width varied from 28 to 48 feet.

The subaqueous part of the work and hydraulic grading were completed September 8, and the shovel grade in October. Work was then suspended until an extreme low stage of water should occur, so that the ballasting could be made as thorough as possible. Work was resumed February 8 and completed February 28, 1892, during which period the ballasting of the bank was carried to the stage of standard high water.

The details of cost and extent of the work are shown in the following statement:

Statement.

Class and extent of work.	Prices of materials.	Cost of each class of work.	Total.
Sinking 44 revetment anchor piles:			
Labor and subsistence		$73.03	
616 linear feet oak piling	$0.17273	106.40	
672 linear feet of cottonwood piling	.093	62.50	
75 bushels coal	.11453	8.59	
50 pounds of 8-inch spikes	.0325	1.62	
			$252.14
Driving 20 cottonwood revetment anchor piles:			
Labor and subsistence		36.77	
560 linear feet of cottonwood piling	.093	52.08	
50 bushels coal	.11453	5.73	
			94.58
Weaving 48,101 square feet = 1,223 linear feet of mattress, and anchoring it at top of bank:			
Labor and subsistence		785.44	
335 cords of brush	1.7398	582.83	
1,700 pounds $\frac{3}{8}$-inch wire cable	.0447	75.99	
100 $\frac{5}{8}$-inch iron cable fastenings	.08	8.00	
100 $\frac{3}{4}$-inch iron cable fastenings	.10	10.00	
			1,462.26
Ballasting 43,198 square feet of mattress below water:			
Labor and subsistence		22.50	
220 cubic yards of stone	.95405	209.89	
			232.39
Grading bank:			
Labor and subsistence, grading 760 linear feet = 1,417 cubic yards, by water jet		102.52	
249 bushels coal	.11453	28.52	
Labor and subsistence, grading 1,490 linear feet by shovel		251.40	
Powder and fuse		11.62	
			394.06
Ballasting 96,983 square feet = 2,250 linear feet of bank with stone:			
Labor and subsistence		865.11	
3,205 cubic yards of stone	.95405	3,057.73	
			3,922.84
Miscellaneous:			
Filling holes in bank with brush		71.31	
Renewing screen fences		29.50	
Administration		66.10	
Incidental expenses		384.32	
Service of steamer Melusina		452.23	
Care and repair of plant in service		288.46	
			1,291.92
Total			7,650.19

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Harlem revetment.—The construction of revetment below Harlem, Mo., was begun in the latter part of the last fiscal year, but had to be entirely suspended after completing 700 feet of mattress on account of high water. The working party and plant were brought from Kaw Bend to Harlem on September 8 and 9 by the *Melusina*, and work resumed on the revetment September 10.

According to the original project, the revetment was to be 2,740 feet long. On account of shallow water, however, 80 feet of mattress at the downstream end could not be constructed.

About the time that the work proposed in the project was completed as far downstream as possible, it became necessary, on account of the bank cutting above the revetment, to extend the work 385 feet further upstream than had been intended.

Subsequently, with your approval, Dike X was constructed about 185 feet below the end of the revetment, between which and the dike the bank was ballasted.

Notwithstanding these extensions and the higher prices paid for labor this and last year, which were about 25 per cent in excess of those paid in former years, the cost of this work is about $5,000 less than was estimated, on account of no expense being incurred for towboat service. The cost per linear foot of complete revetment is $5.34. The mattress and grading were completed October 17, and all other work November 10.

The following statement shows the details of cost and extent of the Harlem revetment:

Statement.

Class and extent of work.	Prices of materials.	Cost of each class of work.	Total.
Sinking 129 revetment anchor piles:			
Labor and subsistence	....	$151.45	
3,526 linear feet cottonwood piles	$0.093	327.92	
200 bushels coal	.11453	22.91	
25 pounds 8-inch spikes	.0325	.81	
			$503.09
Weaving 171,165 square feet = 2,429 linear feet of mattress, and anchoring it at top of bank:			
Labor and subsistence	....	1,587.26	
1,111.5 cords of brush	1.7398	1,933.79	
10,000 pounds [illegible]-inch wire cable	.0447	447.00	
2,000 pounds [illegible]-inch wire cable	.04	80.00	
500 [illegible]-inch iron cable fastenings	.08	40.00	
67 [illegible]-inch iron cable fastenings	.10	6.70	
			4,094.75
Ballasting 167,000 square feet of mattress below water:			
Labor and subsistence	....	125.82	
708.36 cubic yards of stone	.95405	675.81	
			801.63
Grading bank:			
Labor and subsistence, grading 1,305 linear feet = 3,870 cubic yards, by hydraulic grader	....	195.14	
305 bushels of coal	.11453	34.93	
Labor and subsistence, grading and trimming 1,695 linear feet = 1,235 cubic yards, by shovel	....	231.85	
			461.92
Ballasting 180,880 square feet = 3,225 linear feet, of bank with stone:			
Labor and subsistence	....	1,780.26	
4,083 cubic yards of stone	.95405	3,895.39	
			5,675.65
Miscellaneous:			
Administration	....	117.85	
Incidental expenses	....	661.90	
Service of steamer Melusina	....	806.17	
Care and repair of plant in service	....	514.25	
			2,100.17
Amount expended during fiscal year of 1892	....	....	13,637.21
Add amount expended during the fiscal year of 1891	....	....	2,927.88
Total	....	....	16,565.09

East Bottoms revetment.—Slight repairs were made by replacing some of the stone ballast on the East Bottoms revetment, the cost of which work amounted to $116.18.

Kansas City and Harlem dikes.—Dike work was resumed on the Kansas City dikes in September. It was then found that the position of the channel had changed to such an extent since the project for dike work had been approved that Dikes I and II could not be extended, as proposed, without completely closing navigation. For

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this reason Dike I was only extended 60 feet instead of 160 feet; Dike II 262 instead of 300 feet.

Dike III was extended to its proposed full length, by constructing 371 feet of double-row dike and 222 feet of triple-row dike. The unfinished porton of this dike, constructed in June, 1891, consisting of 630 feet of single row and 228 feet of double row dike, was also completed.

The extensions of Dikes I, II, and III are parallel to the old work and lap over it two bents, to insure good connections.

It proved impossible to proceed with the construction of Dike IV, on account of the shallow water at its site.

Dike IX, 280 feet long, was constructed, and a new dike, No. X, was, with your approval, added to the Harlem system. The latter dike is 130 feet long, and is situated between the lower end of the Harlem revetment and Dike V. Dikes IX and X are triple row.

The details of the dike work are the same as used in 1890, excepting that white-oak piles, instead of cottonwood, were used for the outer ten bents of the dikes.

The shore connections of Dikes VII and VIII that were washed away during the June rise of 1891 were rebuilt.

The cost of dike work is as follows, viz:

Completing 630 feet of single-row dike, begun in June, 1891	$184.38
Repairs to Dikes VII and VIII	189.78
Completing 228 feet of double-row dike	270.98
Constructing 431 feet of new double-row dike	1,605.69
Constructing 993 feet of new triple-row dike	7,154.35
Total	9,405.18

The following statements show the cost and extent of double and triple row dike, constructed during the fiscal year of 1892:

Statement of cost of constructing 431 linear feet of double-row dike.

Class and extent of work.	Prices of materials.	Cost of each class of work.	Total.
Sinking 108 dike piles:			
Labor and subsistence		$208.76	
224 bushels of coal	$0.11453	25.65	
60 pounds 8-inch spikes	.0325	1.95	
20 pounds 7-inch spikes	.0325	.65	
3,672 linear feet cottonwood piling	.093	341.50	
			$578.51
Weaving 440 linear feet of foot mat, 20 to 25 feet wide=10,130 square feet:			
Labor and subsistence, weaving		118.06	
Labor and subsistence, ballasting		34.78	
62 cords of brush	1.7398	107.87	
90 cubic yards of stone	.95405	85.86	
50 pounds wire	.037	1.85	
			384.42
Bracing and lashing:			
Labor and subsistence, bracing		88.64	
Labor and subsistence, lashing		46.60	
5,190 feet B. M. lumber	19.5058	101.24	
770 pounds ⅝-inch square iron	.022	16.94	
1,620 linear feet cottonwood wales	.0317	51.35	
950 pounds ⅜-inch wire cable	.0447	42.47	
			343.24
Screening 431 feet of dike:			
Labor and subsistence		51.64	
16 cords of brush	1.7398	27.84	
54 pounds 40-penny nails	.0215	1.16	
70 pounds No. 10 wire	.037	2.59	
			83.23
Miscellaneous:			
Administration		13.87	
Incidental expenses		77.93	
Service of steamer Melusina		94.94	
Care and repair of plant in service		60.55	
			247.29
Total			1,605.69

Cost per linear foot, $3,725.

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Statement of cost of constructing 993 linear feet of triple-row dike.

Class and extent of work.	Prices of materials.	Cost of each class of work.	Total.
Sinking 346 dike piles and 18 anchor piles:			
Labor and subsistence		$729.61	
754 bushels coal	$0.11453	86.36	
190 pounds 8 inch spikes	.0325	6.17	
55 pounds 7-inch spikes	.0325	1.79	
8,100 linear feet cottonwood piles	.093	753.30	
4,656 linear feet oak piles	.17273	804.23	
			$2,381.46
Weaving and ballasting 1,127 linear feet (61,516 square feet) of foot mat:			
Labor and subsistence, weaving mat		716.92	
Labor and subsistence, ballasting mat		211.14	
377 cords brush	1.7398	655.90	
2,300 pounds ⅜ inch wire cable	.0447	102.81	
200 ⅜-inch cable fastenings	.08	16.00	
550 cubic yards of stone	.95405	524.73	
50 pounds No. 10 wire	.037	1.85	
			2,229.35
Bracing and lashing:			
Labor and subsistence, bracing		306.32	
Labor and subsistence, lashing		164.52	
22,496 feet, B. M., lumber	19.5058	438.80	
2,663 pounds ⅜-inch square iron	.022	58.59	
186 pounds 8-inch spikes	.0325	6.04	
2,944 pounds ⅜-inch wire cable	.0447	131.60	
2,970 linear feet wales	.0317	94.15	
			1,200.02
Screening:			
Labor and subsistence		119.00	
36 cords brush	1.7398	62.63	
720 feet, B. M., lumber	19.5058	14.04	
1,080 linear feet cottonwood wales	.0317	34.24	
140 pounds wire	.037	5.18	
120 pounds 40-penny nails	.215	2.58	
125 pounds 7-inch spikes	.0325	4.06	
			241.73
Miscellaneous:			
Administration		61.82	
Incidental expenses		347.25	
Service of steamer Melusina		422.93	
Care and repair of plant in service		269.79	
			1,101.75
Total			7,154.35

Cost of per linear foot, $7.205.

To complete the Kansas City and Harlem dikes and to make them secure, Nos. I and II should be extended 100 feet and 40 feet, respectively, and a new dike constructed near the Winner Bridge, above No. I. The outer ends of all the dikes should be buttressed by wings similar in construction to the main bodies of the dikes. The necessity for this precaution is apparent from an inspection of Plate IV, which shows the shape of the bottom at and under the ends of two of the Harlem dikes.

It is believed that the plan proposed of extending a wing downstream about 80 feet, or until shoal water is reached, will, in most cases, prevent the ends of the dikes from being overturned.

Construction materials.—In conducting operations in the vicinity of Kansas City, Mo., during the fiscal year of 1892, 2,518.5 cords of willow brush were used. Of this quantity 455 cords were on hand at the close of the last fiscal year and 2,063.5 cords procured during the fiscal year of 1892. Of the latter, 1,129.5 cords were purchased, delivered on the river bank, and 1,369 cords procured by hired labor. The average cost of brush, loaded on barges, procured during 1892, was $1.7176 per cord.

Eleven thousand six hundred and forty-seven and thirty-six one-hundredths cubic yards of stone were used in constructing works of improvement, of which 417 yards were on hand at the end of the last fiscal year and 11,230.36 yards purchased at an average cost of $0.94423 per yard.

Seventeen thousand seven hundred and twelve linear feet of cottonwood piles were on hand at the beginning of the last fiscal year, and 8,200 linear feet purchased at 10 cents per linear foot.

Eight thousand nine hundred and forty linear feet of native oak piling were purchased at the mouth of Grand River, at 11 cents per foot, and 8,396 feet of white-oak piling at Kansas City, Mo., at 16.6 cents per foot.

The yellow pine lumber used for bracing the dikes was purchased during the last fiscal year.

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Surveys.—The following special surveys were made under the Kansas City allotments, viz:

At Leavenworth, Kans., in July, to determine the effect produced on the direction of the current of the Missouri River by the spoil banks formed by coal companies throwing shale and slate in the river; at Bee Creek Bend, above Fort Leavenworth, Kans., in August, to determine the extent of erosion in the unprotected part of the bend; in the vicinity of Kansas City, Kans., in September and November, to determine the effect of the dike constructed by the National Water Works Company and others at the mouth of the Kansas River; and at Harlem, Mo., in November and December, to ascertain the extent and shape of the accretions formed by the Harlem dikes, and to determine the boundaries and ownership of the lands adjacent to the dikes.

An examination was also made of the Kansas River at Riverview Bridge to locate the obstructions under that structure.

Reports were submitted on the above surveys, and 10 tracings of maps and drawings relating thereto prepared in the Kansas City office.

The cost af the above surveys amounted to $337.35.

SYSTEMATIC IMPROVEMENT IN THE FIRST REACH.

Projects.—In compliance with your verbal instructions, preliminary projects for the systematic improvement of the Missouri River in the First Reach were submitted under date of April 16, 1891. These projects were in outline, and based on data furnished by the shore-line survey of December, 1890.

By your letter of May 18, 1891, I was advised of the Commission's approval of a part of one of the projects and instructed to proceed with preparations for work, which was to be begun as soon as possible.

It was proposed in the project selected by the Commission to rectify the shore lines of the river between a point one-half mile below the mouth of Moreau River and the head of Dodd Island by reducing the river to a uniform width of 1,000 feet at a stage of about 2 feet above standard low water, and by training it into Osage Chute, between Dodd Island and the right bank.

The principal features of this project consisted in having the rock bluff as a permanent bank on one side of the river over the entire reach which it was desired to improve, and in avoiding the wide and shallow river below Barkersville, which for many years past has been a source of great delay and pecuniary loss to steamboatmen when the river was below a mid-stage.

The means proposed for accomplishing these results consisted of three groups of permeable dikes, referred to as Groups I, II, and III. The dikes composing these groups are designated by numbers on the accompanying map (Plate V). The profiles of the dikes are shown on Plates VI. VII, and VIII.

Group I consists of three dikes, Nos. 1, 2, and 3.

The purposes of these dikes are as follows, viz:

First. To deepen and enlarge the right-hand chute, in which the channel has for several years been close and crooked at low stages of water, by closing the left-hand chute at and above the "towhead."

Second. To diminish the discharge of Harlan Chute so that its effect in changing the direction of flow of the main stream at the foot of Harlan Island would be lessened.

Group II, as proprosed, comprised eight dikes. The construction of three of these, viz, Nos. 9, 10, and 11, was approved. Those not approved consisted of four short dikes between △ Ewing and Dike No. 9, and one dike immediately below the mouth of Rising Creek.

The purpose of the second group of dikes is to prevent the channel from making a short crossing from Rising Creek to Harlan Island by building up a new shore line, with a flatter curvature, outside of the old one, between △ Ewing and Rising Creek.

Nine dikes were proposed in Group III. These dikes were intended to build up a shore line between the foot of the towhead and Barkersville, and to train the river into Osage Chute. The construction of the six dikes, Nos. 13, 14, 16, 17, 18, and 19, and of the parts of Dikes 20, 21, and 22 adjoining the left bank was approved. Subsequently, by your advice, Dikes 13*a* and 13*b* were added to Group III, as the gap between 13 and 14 was considered too great.

In the summer and fall of 1891 borings were made across Osage Chute. From these borings it appeared that the area of the chute down to bed rock, or to the line of probable scour, would be insufficient to pass the whole volume of the Missouri without considerable lateral enlargement of the section by the erosion of a portion of Dodd Island. For this reason the original project was modified, by your direction, in February, 1892.

The proposed modification consists in training the river between Dodd Island and Côte Sans Dessein, instead of turning it into Osage Chute.

By this change in plan Dikes Nos. 16 to 22 were shortened, their direction slightly

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changed, so as to make them normal to the new lines of rectification, and three supplementary dikes, 17*a*, 18*a*, and 19*a*, proposed.

In the spring of 1892 it was estimated that the balance of funds that would probably be available after completing the proposed works between Moreau River and Dodd Island would be sufficient to initiate the improvement of the reach of river between the foot of Murray Bend and the Moreau by deepening the channel over a short but shallow reach situated about 1¼ miles below Jefferson City. In accordance with your instructions, therefore, projects for that improvement were submitted under date of February 9, 1892.

The natural head of the reach is the bluff contact above Stanley Island, and the improvement will finally have to be extended to that point to insure a stable regimen for the river below the foot of Murray Bend.

A plan of complete improvement, however, could not at that time be entertained, on account of its great cost.

It was proposed, in one of the projects submitted, to concentrate the river in the right-hand chute, between Cedar City and Moreau River, by closing the left-hand chute by the five dikes, A, B, C, D, and E; to counteract the effect of the irregular shore line below Jefferson City, which causes the river to cross to the head of Cedar Island, by constructing seven short dikes on the water front of the town; and to prevent a flow from the right into the left hand chute, opposite the head of Cedar Island, by Dikes O and P.

This project being approved in part by the Commission, I received your instructions to proceed with the construction of Dikes O and P when an opportunity for doing so occurred. Dike Q was subsequently added to this group.

Standard high and low water.—A temporary gauge was established at Ewing Landing June 21, 1891, and a permanent one just below the mouth of Rising Creek August 7. The latter is known as the Ewing gauge and is used as the standard gauge in the First Reach. The elevations of the planes of standard low and high water were determined approximately in the summer of 1891 for the Ewing gauge as 108.5 feet and 120.8 feet above St. Louis directrix, respectively. During the past ten months a more complete set of gauge readings was obtained, from which it appears that the elevation of standard high water should be 122 feet. These observations confirm the elevation of standard low water as first determined, *i. e.*, 108.5 feet. The method employed for establishing the elevations of high and low water consisted in ascertaining, for all stages, the relations between the Ewing gauge and the Jefferson City gauge. This was done by plotting simultaneous readings of the two gauges as ordinates and abscissæ, respectively.

As the planes of high and low water for the Jefferson City gauge were already well established, the corresponding elevations on the Ewing gauge were obtained from the relations between the two gauges.

Surveys.—Cross sections of the river were sounded in June, 1891, on the line of each of the dikes. These and other sections situated about halfway between the dikes were frequently sounded at different stages of water during the progress of the work. Discharge measurements were made for about every foot on the gauge of the different chutes formed by the "tow-head," Harlans Island, the middle bar opposite Barkersville, and the middle bars between Cedar City and Moreau River.

Borings were made on twelve sections in the Missouri River above the head of Dodds Island; also on one section in Osage Chute and one in Kate Howard Chute.

The computations of discharge measurements observed up to November 30 and drawings of the borings were forwarded to your office under date of February 10, 1892. The discharge observations made this spring and summer are forwarded as a separate report to the secretary of the Commission.

A complete low-water survey was made of the river between Stanley Island and Fergusons Landing in December, a map of which (Pl. V) is used for reference in this report. Surveys were also made where extensive or important changes in shore line have occurred since December. These changes are shown on the map for Harlans Chute and the "tow-head."

Dike construction.—The design adopted for the dikes in First Reach resembles closely that followed at Kansas City and Harlem in 1889, 1890, and 1891, and is fully described in my reports for those years.

The details, however, differ from those of the dikes formerly constructed in the following particulars, viz:

1st. In using yellow pine instead of cottonwood wales for bracing the dikes longitudinally.

2d. In making the woven foot mat wider.

3d. In constructing a wing under the stream end of each dike, extending downstream 50 to 60 feet, for bracing the ends of the dikes against the effects of severe scour. The wings are of the same construction as double-row dike, and are placed at right angles to the dikes.

4th. In making the dike screen of large poles instead of ordinary willows.

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Pile sinking and driving.—Cottonwood piles were used for the dikes constructed prior to March 1, excepting for nineteen bents at the stream ends of the dikes, for which white-oak piles were used. After March 1 piles of different varieties of native oak were procured, as they were found only slightly more expensive than cottonwood, although greatly superior materials.

The piles were sunk by the water jet or driven either by a Cram steam hammer, a steam pile-driver, or horse pile-drivers. The water jet was used in preference to the other methods where there was sufficient water to float a pile-sinker or the materials forming the ground could be penetrated by the jet, as better speed could be made at less cost than by the other methods and a better line maintained for the dike piles.

Three different types of pile-sinkers were used. These differed only in the arrangement of the leads on the cross boat, as follows, viz: The old type of sinker, with derrick, high platform, and two sets of leads; a three-lead sinker, first used at Kansas City in 1889, and a six-lead sinker, which was used for the first time in the First Reach. The latter apparatus was designed for working from the shore outward, on either side of the river, with the main boat lying against the upstream line of piles.

During four consecutive days, when the three-lead sinker worked continuously on one dike, 148 piles were sunk, with a total penetration of 3,468 feet. The best day's work done by one sinker consisted in sinking 48 piles, with a penetration of 1,100 feet.

A Cram steam hammer was used for the pile work on dikes 9 and 10. It was mounted in a set of leads 52 feet high, placed on the end of a 100-foot barge. The machine is one of the largest size; it has a 40-inch stroke, and weighs about 8,400 pounds. The hammer, or ram, weighs about 5,500 pounds. The hammer was run at a speed of about 52 blows per minute, with an average stroke of 38 inches. When no delay occurred, from parts of the apparatus breaking, etc., a day's work consisted in driving about 31 piles through sand and gravel, with a total penetration of about 570 feet.

The performance of the machine was very satisfactory. The piles were driven to a penetration of about 25 feet, or until they shattered to such an extent that they could not be driven any farther. Cottonwood piles sometimes began to shatter after receiving about fifty blows and attaining a penetration of only 10½ feet, although one pile received 420 blows, getting a penetration of 23¼ feet, before it began to shatter. An oak pile received 814 blows, penetrating 21½ feet, before shattering.

A steam pile-driver with a 1,600-pound hammer, mounted on a 64-foot barge, was used to drive piles at the shore ends of dikes and to close gaps left between sections of pile work where there was not enough space to handle one of the large pile-sinkers.

Two horse pile-drivers, with 800 and 1,200 pound hammers, were used during the winter months to drive piles for the first group of dikes after it was discovered that the Cram hammer could not be operated on account of the boilers furnished for it being too small. They were unsatisfactory on account of being slow and expensive, and in not being able to give enough penetration.

The following table shows the details of pile-sinking and pile-driving by the above methods on the dikes in the First Reach during the fiscal year of 1892.

Table.

Number or letter of dike.	Number of piles, average penetration, and method of sinking.							
	Water jet.		Cram hammer.		Steam driver.		Horse drivers.	
	Number.	Average penetration.	Number.	Average penetration.	Number.	Average penetration.	Number.	Average penetration.
1	390	21.5	30	22.3	80	17.8	480	9.9
2	815	22.1			58	21.0	64	9.9
3	767	19.9			90	17.6	146	10.9
9	108	23.4	13	21.7			3	14.0
10			207	18.7				
11	9	20.1	258	17.9				
13	279	22.7						
13a	380	22.8						
13b	318	22.8	12	21.5				
14	372	22.5	13	24.8	39	19.7		
16	60	21.9			13	20.8		
17	45	20.2						
O	262	22.5						
P	268	22.0						
Q	80	22.1						
Total	4,153	21.8	533	18.8	280	18.9	693	10.1

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Foot mattress.—As above stated, the dike foot mat was made wider for the dikes in the First Reach than for those constructed in the vicinity of Kansas City. This change was considered advisable, as a greater scour was expected to occur on account of the periods of high water being longer than at Kansas City.

The widths of foot mat as constructed in the First Reach are as follows, viz: For single-row dike, 11 to 15 feet; for double-row dike, 21 to 30 feet, and for triple-row dike, 35 to 50 feet. Where the mat was made of the lesser widths, the upper edge projected 5 feet above the upper line of piling in the double-row dike, and 10 feet above in the triple-row dike. Whenever a wider mat was used, the extra width was given to that part of the mat above the upper line of piles. At 100 feet from the stream end of the pile work the width of the mat was gradually increased so as to be 65 or 70 feet wide at the outer bent of piles, beyond which point it was carried 40 feet. It was also extended downstream around the wing.

While the mat was under construction in a swift current it was prevented from being turned under by three-eighths inch wire cables extending through it and attached above the surface of the water to mooring piles. The latter were placed above the upper edge of the mat a distance of about five times the depth of water at the dike. The mooring piles and cables were placed from 20 to 60 feet apart, depending on the velocity of the current. As it also proved impossible to prevent a wide mat from rolling under while being sunk in the swift currents often encountered, another set of cables was carried through the mat and made fast around the mooring piles where the latter entered the ground, the end of each cable that was wound around the pile being forced to the bottom by a pike pole. After this arrangement of anchor cables was introduced no difficulty was experienced in sinking the mat, lying above the piles, even and close to the bottom.

It sometimes proved difficult to get the mat sunk between the dike piles without excessive ballasting, on account of its binding against the piles. This difficulty was finally overcome by using a device somewhat similar to that employed on the Atchison dikes. This consisted in leaving openings in the mat by weaving it around barrels suspended from the piles by wire bales.

Bracing dikes.—As the quantity and size of the floating driftwood in the Missouri is greater below Grand River than above, it was thought advisable to make the dike bracing stronger than formerly. This was done by using 6 by 8 inch and 6 by 6 inch yellow pine lumber for bracing the piles of the outer 150 feet and the main bodies of the dikes, respectively, instead of the cottonwood wales used hitherto for that purpose, over the entire length of dike.

The diagonal and transverse braces are of the same dimensions as employed in former work; also the method of attaching them to the piles by five-eighths-inch drift bolts and three-eighths-inch cable lashings.

Dike screen.—The screen formerly used has not proved entirely satisfactory, on account of being too weak and the fastenings not holding. The following plan was therefore devised, viz:

Sharpened poles 2½ to 3½ inches in diameter, spaced about 1½ inches in the clear, were forced through the foot mat and nailed to the upper face of the downstream wales by 20-penny or 30-penny wire car nails. When the distance between the foot mat and the wales was greater than 10 feet, and the stage of water permitted, the poles were also nailed to 4 by 4 inch pine stringers, which were spiked to the lower line of piling, halfway between the wales and the foot mat.

Group I.—Pile-sinking was begun on the first group of dikes July 9. Every effort was made to get it completed before the stage of water declined enough to make it too shallow to float the pile-sinkers over the sand bars on the line of the dikes.

The construction of foot mat was begun August 13. It was desired to begin this work sooner, but it was impossible to get the necessary brush, as the patches were too muddy to use teams in hauling, on account of being overflowed by the preceding June rise. Between August 15 and 20 the river rose 6 feet. According to the records of the Jefferson City gauge, a rise of such magnitude at this time of the year was entirely unprecedented. It was accompanied by a great deal of driftwood, which was blown by a strong south wind to the north side of the river, where it lodged against the dike piles. As the piles had not been braced, the lumber ordered for that purpose not having arrived, about 250 piles out of 1,000 that had been sunk were bent over, washed out, or broken off.

Immediately after the rise the river declined rapidly to a one-third stage, and left the dike piles filled with tangled masses of driftwood and surrounded by sand bars separated by sloughs and shallow chutes. This made it impossible to complete the dikes until the river was frozen or there was another high stage of water. Wherever there was sufficient water to operate the floating plant, however, work was carried ahead on this group.

As it was of the highest importance that these dikes should be completed before the spring floods occurred, it was decided to finish them, if possible, during the

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winter and to use the Cram steam hammer for pile-driving. A party was accordingly organized early in December, and quartered on three small quarter-boats placed under the stream end of Dike 2. The necessary lumber, piles, and brush were distributed on the lines of the dikes, and arrangements made for the purchase of stone, to be delivered at the dikes from a quarry on the Callaway County side of the river.

The Cram steam hammer and leads were also taken to the bar and gotten ready for service. The boiler purchased for operating the hammer now proved too small for that purpose, and a larger one was procured, under a guaranty from the dealer. This latter boiler also proved too small.

As over a month had been lost in trying to get the hammer to work, and very little time remained until the river might be expected to open, it was decided not to get another boiler, but to drive the piles by horse pile-drivers. In the meanwhile mat-weaving and dike-bracing progressed as well as could be expected with unfavorable weather to contend with. Very little mat, however, was ballasted, as only a small quantity of the stone engaged was furnished on account of the almost impassable condition of the road between the quarry and the dikes.

As there appeared to be no probability of getting the quantity of stone required until the river rose several feet in the spring, several expedients were employed to prevent the unballasted mat from floating when the river rose. These consisted in burying the upstream edge of the mat in a deep furrow, and in spiking cleats to the piles on top of the mat. Although the latter device answered in some cases, wherever scour occurred under the mat that action was increased by the mat floating on account of not being ballasted. Work continued until February 8, when it had to be suspended for several days on account of a rise in the river.

Most of the unused dike materials lying on the ice and sand bars were now gathered up and lashed on top of the dikes, when another sudden rise occurred, which resulted in 140 feet of unballasted foot-mat on Dike 3 being washed out. About 320 feet of unfinished double-row dike on Dike 1 was also damaged.

Advantage was taken of the opportunity given by this rise to get several barge loads of stone to the dikes, wherever the water was deep enough, so as to ballast the foot-mat that could be reached, where this had not already been done.

Another sharp rise occurred in March, which swept away the 320 feet of Dike 1 which was damaged in February, but which it had not been possible to repair on account of the water being too shallow to get plant and materials to the dike.

As the part of the dike that had been breached was now accessible it was rebuilt, and was completed just in time to avoid being again destroyed by another rise in the latter part of March. Dike 3 was also completed at this time. During the latter rise about 200 feet of double-row dike at the shore end of Dike 1, where the dike crosses the bed of an old slough, was washed out.

Work was resumed at the outer end of Dike 2 April 10, and the dike completed to within 70 feet of its full length early in May. This practically completed the first group of dikes, on which no further work was done during the remainder of the fiscal year.

During the extreme high stage of water in April and May, breaches occurred near the shore ends of Dikes 2 and 3. These breaches were through the single and double-row dike which was hurriedly constructed in February so as to have the dikes completed before the ice in the river broke up. Most of the foot-mat was unballasted, as it was impossible, as explained above, to get the stone for that purpose. The dike piles were also driven by horse hammer-drivers, the only means then available, and could not be given very deep penetrations. The extent of dike washed out in the first group during the extreme high water in May was 646 feet of single row, 685 feet of double row, and 250 feet of triple row.

During the higher stages of water the upper end of the "towhead" was gradually washed away (see Plate V), and about 70 feet of Dike 3, where it joined the "towhead," destroyed.

Group II.—The construction of the second group of dikes was begun as soon as it was made impossible, by shallow water, to proceed further with the first group.

It was found, however, that piles could not be sunk by the waterjet through the bed of coarse gravel, sand, and disintegrated rock of which the bottom is composed at Dikes 10 and 11. When this was made evident, it was decided, after consulting with you, to procure a Cram steam hammer for driving the piles at those dikes, as that apparatus appeared to be better adapted to giving deeper penetrations to the cottonwood piles, without shattering them, than was possible with a steam pile-driver. The hammer, leads, and a 20-horse power Lidgerwood engine and boiler were accordingly purchased and driving begun in the latter part of October.

The dikes were entirely completed to within about 150 feet of their proposed ends in December. They were not constructed full length, as it was thought that by doing so the width of the channel between them and the "towhead" would be too greatly reduced. The ice was cut away around the ends of the dikes in the latter

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part of January, and went out without injury to them when the river opened. During the recent high water these dikes were subjected to as severe a test from that source as can ever be expected, without damage.

Group III.—The construction of Dikes 13, 13*a*, 13*b*, and 14, of the third group, was begun August 29, and continued until the early part of December, at which time work was suspended on account of the extreme low stage of water. Work was resumed in the latter part of March, and the dikes completed, excepting 200 feet of screen on Dike 14, early in April.

The construction of Dikes 16 and 17 was begun in the latter part of March, but work on them had to be suspended early in April on account of the high water.

During the rise in the river that occurred between March 7 and 15, a breach of about 150 feet was made through the middle of Dike 13. Sections sounded on the line of the dike, before the breach occurred and immediately afterwards, are shown on Plate IX. It appears from these sections that the breach is situated where there had been, on June 4, 1891, a well defined channel.

When the dike was constructed in September, the current at that part of the river was very sluggish, in consequence of which the channel was filled up with very fine sediment.

It is probable, notwithstanding the conditions described, that the dike would not have been damaged if those in Group I could have been completed before the river rose in March. During that rise, however, a section of foot-mat washed out from Dike 3 and lodged on Dike 13. Fragments of broken dikework from Dikes 1 and 3 and an immense quantity of driftwood accumulated against the section of mat and along the upper side of the dike, making a dam, through the upper part of which there was practically no escape for the water. In consequence the current was deflected to the bottom, and scour took place around some of the piles, until they did not have sufficient penetration left to withstand the pressure against the dike.

During the extreme high water between May 10 and 15 the bank behind Dike 13*b* was cut away for about 125 feet. No damage was done to the dike, however, excepting to wash out the mat at the shore end. The cause of this occurrence is very obscure. It happened while the dike was entirely covered by water. With the exception of the breach in Dike 13, the dikes in the third group are in perfect condition.

Cedar Island dikes.—When work was suspended at Dikes 16 and 17 one of the construction parties was moved to the head of Cedar Island and work begun at Dike O April 19. A second party began work at Dike P April 29.

All necessary preparations had now been made and the organization of the parties perfected, so that it was expected to carry on work rapidly and economically. Stormy weather and almost constant rains, however, interfered and prevented satisfactory progress being made.

On account of a rapid downstream movement of the crossing, and the bars above and below it opposite the head of Cedar Island, it became evident that, if Dikes O and P were constructed as planned, they would lie entirely across the lower end of a large channel which had been formed within a few weeks, as above described. It was therefore decided, in a consultation with you on May 2, to complete only about 800 feet of Dike O, to change the plan of Dike P by making the outer 1,000 feet normal to the direction of the current on the crossing, and to construct another dike (Q) 1,000 to 2,000 feet below Dike P.

On the night of May 4 the river rose 2 feet, bringing a large quantity of very heavy driftwood and large sawlogs, which gathered against Dike O. Every effort was made to get the foot-mat sunk and the piles braced, but with only partial success, and several hundred feet of unfinished dike were lost. The construction of Dike Q was carried on until May 9, when it was suspended on account of the extreme high water, as it was evident that by attempting to proceed any further a great risk would be incurred of losing more work.

During the past year the fall has proved the most favorable season for dike construction, and spring the most unfavorable. During the former work was not interfered with to any great extent by rain or stormy weather, and the change in stage of water was gradual, whereas during the latter season the reverse conditions prevailed.

The work done during the winter has been very expensive on account of having to subsist the working parties at times when they could not work on account of extreme cold or stormy weather, also on account of having to transport construction materials by teams or carry them by hand.

The extent of the dike work constructed in first reach is given in the following table:

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Table.

Group.	Number or letter of dike.	Lengths in feet. Single row.	Double row.	Triple row.	Totals. In dikes.	In groups.
I	1	864	*1,754	885	3,183	
	2	100	1,258	1,475	2,833	
	3	280	460	2,400	3,140	
Totals		1,244	3,472	4,760		9,476
II	9		45	294	339	
	10		60	480	540	
	11		60	626	686	
Totals			165	1,400		1,565
III	13			767	767	
	13a			916	916	
	13b		60	960	1,020	
	14		60	1,031	1.091	
	16			207	207	
	17			120	120	
Totals			120	4,001		4,121
Cedar Island	O			245	245	
	P			650	650	
	Q		389		389	
Totals			389	895		1,284
Total						16,446

*Includes the 320 feet destroyed and reconstructed in March.

The following statements give the details of cost and extent of each class of work for single, double, and triple-row dike in each group constructed in the First Reach during the fiscal year ending June 30, 1892:

Statement of cost and extent of work in Group I.

Extent of work and quantities of materials in 1,244 linear feet single-row dike.	Prices of materials.	Cost of each class of work.	Total.
Sinking 5 dike piles by jet:			
Labor and subsistence		$7.38	
8 bushels coal	$0.10844	.87	
173 linear feet cottonwood piles	.095805	16.57	
			$24.82
Driving 140 dike piles by horse driver:			
Labor and subsistence		318.26	
2,159 linear feet cottonwood piles	.095805	206.85	
			525.11
Weaving 18,990 square feet of foot mat:			
Labor and subsistence		204.15	
110 cords brush	2.65622	292.18	
			496.33
Ballasting 13,375 square feet of foot mat:			
Labor and subsistence		54.79	
75 cubic yards of stone	1.02348	76.76	
			131.55
Bracing 1,244 linear feet of dike:			
Labor and subsistence		70.61	
10 pieces 4 by 6 inches by 22 feet pine lumbrr = 440 feet, B. M.	20.44856	9.00	
48 pieces 6 by 6 inches by 26 feet pine lumber = 3,744 feet, B. M.	21.72488	81.34	
470 pounds ⅝-inch square iron	.01921	9.03	
			169.98
Screening 1,209 linear feet of dike:			
Labor and subsistence		169.00	
45 cords brush	2.65622	119.53	
27 pounds 8 by ½ inch spikes	.024	.65	
124 pounds 20-penny wire nails	.03025	3.75	
60 pounds 30-penny wire nails	.03025	1.82	
			294.75
Cost of 1,244 linear feet single-row dike			1,642.54

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Statement of cost and extent of work in Group I—Continued.

Extent of work and quantities of materials in 3,472 linear feet double-row dike.	Prices of materials.	Cost of each class of work.	Total.
Sinking 286 dike piles by jet:			
Labor and subsistence		$391.99	
435 bushels coal	$0.10844	47.17	
84 pounds 7 by ¼ inch spikes	.03	2.52	
9,919 linear feet cottonwood piles	.095805	950.29	
			$1,391.97
Driving 10 dike piles by Cram hammer:			
Labor and subsistence		16.94	
13 bushels coal	.10844	1.41	
354 linear feet cottonwood piles	.095805	33.91	
			52.26
Driving 84 dike piles by steam driver:			
Labor and subsistence		248.75	
155¾ bushels coal	.10844	16.89	
2,414 linear feet cottonwood piles	.095805	231.28	
			496.92
Driving 232 dike piles by horse driver:			
Labor and subsistence		607.77	
4,321 linear feet cottonwood piles	.095805	413.97	
			1,021.74
Weaving 75,165 square feet of foot mat:			
Labor and subsistence		808.04	
445.73 cords brush	2.65622	1,183.96	
			1,992.00
Ballasting 67,895 square feet of foot mat:			
Labor and subsistence		278.11	
437.6 cubic yards stone	1.02348	447.89	
			726.00
Bracing 3,472 linear feet of dike:			
Labor and subsistence		326.11	
334 pieces 4 by 6 inches by 12 feet pine lumber = 8,016 feet, B. M.	18.93653	151.80	
646 pieces 4 by 6 inches by 15 and 16 feet pine lumber = 19,380 feet, B. M	19.657	380.95	
58 pieces 4 by 6 inches by 22 feet pine lumber = 2,552 feet, B. M.	20.44856	52.18	
204 pieces 6 by 6 inches by 26 feet pine lumber = 15,912 feet, B. M.	21.72488	345.69	
4 pieces 6 by 8 inches by 26 feet pine lumber = 416 feet, B. M.	24.83636	10.34	
4,008 pounds ⅝-inch square iron	.01921	76.99	
589 pounds 8 by ½ inch spikes	.024	14.14	
			1,358.20
Lashing 3,152 linear feet of dike:			
Labor and subsistence		78.69	
7,588 linear feet ⅜-inch wire cable	.011832	89.78	
			168.47
Screening 1,774 linear feet of dike:			
Labor and subsistence		247.98	
65 wales	.834	54.21	
60 cords brush	2.65622	159.37	
65 pounds 8 by ½ inch spikes	.024	1.56	
168 pounds 20-penny wire nails	.03025	5.08	
87 pounds 30-penny wire nails	.03025	2.63	
			470.83
Cost of 3,472 linear feet of double-row dike			7,678.39

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Statement of cost and extent of work in Group I—Continued.

Extent of work and quantities of materials in 4,760 linear feet triple-row dike.	Prices of materials.	Cost of each class of work.	Total.
Sinking 1,673 dike piles by jet:			
Labor and subsistence		$2,495.70	
2,547 bushels coal	$0.10844	276.17	
353 pounds 7 by ½ inch spikes	.03	10.59	
110 pounds ⅜-inch round iron	.025	2.72	
49,734 linear feet cottonwood piles	.095805	4,764.79	
3,626 linear feet native-oak piles	.11148	404.25	
4,962 linear feet white-oak piles	.16951	841.11	
			$8,795.33
Driving 15 dike piles by Cram hammer:			
Labor and subsistence		25.39	
20 bushels coal	.10844	2.17	
531 linear feet cottonwood piles	.095805	50.87	
			78.43
Driving 122 dike piles by steam driver:			
Labor and subsistence		556.84	
226 bushels coal	.10844	24.50	
3,310 linear feet cottonwood piles	.095805	317.11	
562 linear feet native-oak piles	.11148	62.65	
			961.10
Driving 359 dike piles by horse driver:			
Labor and subsistence		1,543.90	
6,570 linear feet cottonwood piles	.095805	629.46	
			2,173.36
Sinking 24 mooring piles by jet:			
Labor and subsistence		102.51	
92 bushels coal	.10844	9.98	
730 linear feet cottonwood piles	.095805	69.94	
204 linear feet native-oak piles	.11148	22.74	
			205.17
Driving 8 mooring piles by steam driver:			
Labor and subsistence		40.72	
50 bushels coal	.10844	5.42	
160 linear feet cottonwood piles	.095805	15.33	
136 linear feet native-oak piles	.11148	15.16	
			76.63
Weaving 223,548 square feet of foot mat:			
Labor and subsistence		2,403.18	
1,338¼ cords brush	2.65622	3,555.37	
8,984 linear feet ⅜-inch wire cable	.011832	106.30	
403 pounds No. 10 wire	.0309	12.45	
			6,077.30
Ballasting 163,291 square feet of foot mat:			
Labor and subsistence		668.86	
1,366.18 cubic yards stone	1.02348	1,398.29	
			2,067.15
Bracing 4,760 linear feet of dike:			
Labor and subsistence		1,744.38	
2,608 pieces 4 by 6 inch, by 15 and 16 feet pine lumber = 78,740 feet, B. M	19.657	1,547.79	
793 pieces 4 by 6 inch by 22 feet pine lumber = 34,892 feet, B. M.	20.44856	713.49	
631 pieces 6 by 6 inch by 26 feet pine lumber = 49,218 feet, B. M.	21.72488	1,069.25	
13,159 pounds ⅝-inch square iron	.01921	252.87	
1,890 pounds 8 by ½ inch spikes	.024	45.35	
			5,373.13
Lashing 4,488 linear feet of dike:			
Labor and subsistence		266.78	
25,725 linear feet ⅜-inch wire cable	.011832	304.38	
			571.16
Screening 4,215 linear feet of dike:			
Labor and subsistence		589.18	
85 pieces 4 by 4 inch by 17 feet pine lumber = 793 feet, B. M	19.9809	15.84	
243 wales	.834	202.66	
150 cords brush	2.65622	398.43	
110 pounds 8 by ½ inch spikes	.024	2.64	
353 pounds 20-penny wire nails	.03025	10.68	
285 pounds 30-penny wire nails	.03025	8.62	
			1,228.05
Cost of 4,760 linear feet of triple-row dike			27,606.81

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Statement of cost and extent of work in Group II.

Extent of work and quantities of materials in 165 linear feet of double-row dike.	Prices of materials.	Cost of each class of work.	Total.
Driving 32 dike piles by Cram hammer.			
Labor and subsistence	....	$54.19	
43 bushels coal	$0.10844	4.66	
854 linear feet cottonwood piles	.095805	33.91	
868 linear feet native oak piles	.11148	96.77	$189.53
Weaving 12,600 square feet of foot mat:			
Labor and subsistence	....	135.45	
74.72 cords brush	2.65622	198.47	333.92
Ballasting 12,600 square feet of foot mat:			
Labor and subsistence	....	51.61	
185 cubic yards stone	1.02348	189.34	240.95
Bracing 165 linear feet of dike:			
Labor and subsistence	....	6.75	
15 pieces 4 by 6 inches by 12 feet pine lumber = 360 feet, B. M.	18.93653	6.81	
30 pieces 4 by 6 inches by 15 and 16 feet pine lumber=960 feet, B. M.	19.657	18.87	
10 pieces 6 by 8 inches by 26 feet pine lumber = 1,040 feet, B. M	24.83636	25.83	
203 pounds ⅝-inch square iron	.01921	3.95	
58 pounds 8 by ½ inch spikes	.024	1.39	63.60
Lashing 165 linear feet of dike:			
Labor and subsistence	....	4.42	
426 linear feet ⅝-inch wire cable	.011832	5.04	9.46
Screening 165 linear feet of dike:			
Labor and subsistence	....	25.16	
17 cords brush	2.65622	45.16	
7 pounds 8 by ½ inch spikes	.024	.17	
34 pounds 20-penny wire nails	.03025	1.03	
9 pounds 30-penny wire nails	.03025	.27	71.79
Cost of 165 linear feet double-row dike	....	....	909.25

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Statement of cost and extent of work in Group II—Continued.

Extent of work and quantities of materials in 1,400 linear feet triple-row dike.	Prices of materials.	Cost of each class of work.	Total.
Sinking 85 dike piles by jet:			
Labor and subsistence		$126.80	
129 bushels coal	$0.10844	13.96	
30 pounds 7 by ½ inch spikes	.03	.90	
867 linear feet cottonwood piles	.095805	83.06	
2,173 linear feet white-oak piles	.16951	368.36	
			$593.08
Driving 462 dike piles by Cram hammer:			
Labor and subsistence		782.21	
617 bushels coal	.10844	66.90	
100 bushels "Big Muddy" coal	.166	16.60	
11,072 linear feet cottonwood piles	.095805	1,060.77	
434 linear feet native-oak piles	.11148	48.39	
4,999 linear feet white-oak piles	.16951	847.88	
			2,822.25
Driving 3 dike piles by horse driver:			
Labor and subsistence		12.90	
56 linear feet cottonwood piles	.095805	5.36	
			18.26
Sinking 12 mooring piles by jet:			
Labor and subsistence		51.26	
46 bushels coal	.10844	4.99	
420 linear feet cottonwood piles	.095805	40.24	
			96.49
Weaving 70,569 square feet of foot mat:			
Labor and subsistence		758.63	
422 cords brush	2.65622	1,120.92	
7,000 linear feet ⅜-inch wire cable	.011832	82.83	
303 pounds No. 10 wire	.0309	9.37	
			1,971.75
Ballasting 64,639 square feet of foot mat:			
Labor and subsistence		264.77	
540 cubic yards stone	1.02348	552.69	
			817.46
Bracing 1,400 linear feet of dike:			
Labor and subsistence		476.45	
756 pieces 4 by 6 inch by 15 and 16 feet pine lumber = 22,680 feet, B. M	19.657	445.82	
189 pieces 4 by 6 inches by 22 feet pine lumber = 8,316 feet, B. M.	20.44856	170.05	
125 pieces 6 by 6-inches by 26 feet pine lumber = 9,750 feet, B. M.	21.72488	211.82	
60 pieces 6 by 8-inches by 26 feet pine lumber = 6,240 feet, B. M.	24.83636	154.98	
3,120 pounds ⅝-inch square iron	.01921	59.94	
799 pounds 8 by ½ inch spikes	.024	19.18	
			1,538.24
Lashing 1,400 linear feet of dike:			
Labor and subsistence		72.75	
7,014 linear feet ⅜-inch wire cable	.011832	82.98	
			155.73
Screening 1,400 linear feet of dike:			
Labor and subsistence		196.25	
46 pieces 4 by 4 inch by 17 feet pine lumber = 1,043 feet, B. M.	19.9809	20.84	
60 cords brush	2.65622	159.37	
61 pounds 8 by ½ inch spikes	.024	1.46	
154 pounds 20-penny wire nails	.03025	4.66	
69 pounds 30-penny wire nails	.03025	2.09	384.67
Cost of 1,400 linear feet triple-row dike			8,397.93

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Statement of cost and extent of work in Group III.

Extent of work and quantities of materials in 120 linear feet double-row dike.	Prices of materials.	Cost of each class of work.	Total.
Sinking 52 dike piles by jet:			
Labor and subsistence		$71.27	
78¼ bushels coal	$0.10844	8.48	
22 pounds 7 by ⅜ inch spikes	.03	.66	
1,803 linear feet cottonwood piles	.095805	172.75	
			$253.16
Driving 12 dike piles by Cram hammer:			
Labor and subsistence		20.32	
16 bushels coal	.10844	1.74	
198 linear feet cottonwood piles	.095805	18.97	
217 linear feet white-oak piles	.16951	36.79	
			77.82
Weaving 9,698 square feet of foot mat:			
Labor and subsistence		104.26	
57½ cords brush	2.65622	152.73	
			256.99
Ballasting 8,400 square feet of foot mat:			
Labor and subsistence		39.72	
62½ cubic yards stone	1.02348	63.97	
			103.69
Bracing 120 linear feet of dike:			
Labor and subsistence		4.50	
12 pieces 4 by 6 inches by 12 feet pine lumber = 288 feet, B. M.	18.93653	5.45	
24 pieces 4 by 6 inches by 15 and 16 feet pine lumber = 768 feet, B. M.	19.657	15.10	
8 pieces 6 by 8 inches by 26 feet pine lumber = 832 feet, B. M.	24.83636	20.66	
123 pounds ⅝-inch square iron	.01921	2.38	
42 pounds 8 by ½-inch spikes	.024	1.01	
			49.10
Lashing 120 linear feet of dike:			
Labor and subsistence		2.86	
276 linear feet ⅜ inch wire cable	.011832	3.26	
			6.12
Screening 120 linear feet of dike:			
Labor and subsistence		16.77	
12 cords brush	2.65622	31.88	
4 pounds 8 by ½ inch spikes	.024	.10	
6 pounds 20-penny wire nails	.03025	.18	
28 pounds 30-penny wire nails	.03025	.85	49.78
Cost of 120 linear feet double-row dike			796.66

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Statement of cost and extent of work in Group III—Continued.

Extent of work and quantities of materials in 4,001 linear feet triple-row dike.	Prices of materials.	Cost of each class of work.	Total.
Sinking 1,405 dike piles by jet:			
Labor and subsistence	....	$2,095.89	
2,139 bushels coal	$0.10844	231.92	
178 pounds 7 by ⅜ inch spikes	.03	5.34	
677 pounds 8 by ⅜ inch spikes	.02452	16.60	
90 pounds ⅝-inch round iron	.025	2.23	
38,774 linear feet cottonwood piles	.095805	3,714.77	
4,017 linear feet native-oak piles	.11148	447.84	
6,303 linear feet white-oak piles	.16951	1,068.43	
			$7,583.02
Driving 59 dike piles by steam driver:			
Labor and subsistence	....	269.28	
109 bushels coal	.10844	11.82	
1,453 linear feet cottonwood piles	.095805	139.20	
429 linear feet native-oak piles	.11148	47.82	
			468.12
Sinking 11 mooring piles by jet:			
Labor and subsistence	....	46.97	
42 bushels coal	.10844	4.55	
388 linear feet cottonwood piles	.095805	37.17	
			88.69
Weaving 152,636 square feet of foot mat:			
Labor and subsistence	....	1,651.62	
919 cords brush	2.65622	2,441.08	
6,700 linear feet ⅜-inch wire cable	.011832	79.26	
403 pounds No. 10 wire	.0309	12.45	
			4,184.41
Ballasting 152,636 square feet of foot mat:			
Labor and subsistence	....	736.43	
1,505.19 cubic yards stone	1.02348	1,540.56	
			2,276.99
Bracing 4,001 linear feet of dike:			
Labor and subsistence	....	1,239.06	
1,952 pieces 4 by 6 inches by 15 and 16 feet pine lumber = 58,822 feet, B. M	19.657	1,156.26	
488 pieces 4 by 6 inches by 22 feet pine lumber = 21,472 feet, B. M	20.44856	439.07	
532 pieces 6 by 6 inches by 26 feet pine lumber = 41,496 feet, B. M	21.72488	901.50	
203 wales	.834	169.30	
8,750 pounds ⅞-inch square iron	.01921	168.09	
1,950 pounds 8 by ⅜ inch spikes	.024	46.80	
			4,120.08
Lashing 3,964 linear feet of dike:			
Labor and subsistence	....	188.71	
18,197 linear feet ⅜-inch wire cable	.011832	215.31	
			404.02
Screening 3,280 linear feet of dike:			
Labor and subsistence	....	458.48	
100 pieces 4 by 4 inches by 17 feet pine lumber = 2,267 feet, B. M	19.9809	45.30	
97 wales	.834	80.90	
110½ cords brush	2.65622	293.51	
101 pounds 8 by ⅜-inch spikes	.024	2.42	
161 pounds 20-penny wire nails	.03025	4.87	
352 pounds 30-penny wire nails	.03025	10.64	
			896.12
Cost of 4,001 linear feet triple-row dikes	....	....	20,021.45

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Statement of cost and extent of work in Cedar Island group.

Extent of work and quantities of materials in 389 linear feet double-row dike.	Prices of materials.	Cost of each class of work.	Total.
Sinking 80 dike-piles by jet:			
Labor and subsistence	....	\$109.64	
122 bushels coal	\$0.10844	13.22	
60 pounds 8 by $\frac{3}{8}$-inch spikes	.02452	1.47	
2,522 linear feet native oak piles	.11148	281.16	\$405.49
Sinking 15 mooring-piles by jet:			
Labor and subsistence	....	64.06	
58 bushels coal	.10844	6.29	
507 linear feet native oak piles	.11148	56.52	126.87
Weaving 13,770 square feet of foot-mat:			
Labor and subsistence	....	148.03	
81.55 cords brush	2.65622	216.61	
2,600 linear feet $\frac{3}{8}$-inch wire cable	.011832	30.76	395.40
Ballasting 13,770 square feet of foot-mat:			
Labor and subsistence	....	56.40	
220.79 cubic yards stone	1.02348	225.97	282.37
Bracing 389 linear feet of dike:			
Labor and subsistence	....	40.88	
80 pieces 4 by 6 inches by 15 and 16 feet pine lumber = 2,560 feet B. M	19.657	50.32	
20 pieces 4 by 6 inches by 22 feet pine lumber = 880 feet B. M	20.44856	17.99	
40 pieces 6 by 6 inches by 26 feet pine lumber = 3,120 feet B. M	21.72488	67.78	
487 pounds $\frac{5}{8}$-inch square iron	.01921	9.36	
69 pounds 8 by $\frac{1}{2}$-inch spikes	.024	1.66	187.99
Lashing 389 linear feet of dike:			
Labor and subsistence	....	10.37	
1,000 linear feet $\frac{3}{8}$-inch wire cable	.011832	11.83	22.20
Cost of 389 linear feet double-row dike	....	....	1,420.32

Extent of work and quantities of materials in 895 linear feet triple-row dike.	Prices of materials.	Cost of each class of work.	Total.
Sinking 530 dike-piles by jet:			
Labor and subsistence	....	\$790.64	
807 bushels coal	\$0.10844	87.50	
388 pounds 8 by $\frac{3}{8}$-inch spikes	.02452	9.51	
1,041 linear feet cottonwood piles	.095805	99.73	
17,777 linear feet native oak piles	.11148	1,981.80	\$2,969.18
Sinking 50 mooring-piles by jet:			
Labor and subsistence	....	213.56	
1,462 linear feet cottonwood piles	.095805	140.07	
192 bushels coal	.10844	20.82	
275 linear feet native oak piles	.11148	30.66	405.11
Weaving 63,830 square feet of foot-mat:			
Labor and subsistence	....	686.19	
382 cords brush	2.65622	1,014.68	
9,300 linear feet $\frac{3}{8}$-inch wire cable	.011832	110.04	1,810.91
Ballasting 50,750 square feet of foot-mat:			
Labor and subsistence	....	207.88	
498 cubic yards stone	1.02348	509.69	717.57
Bracing 858 linear feet of dike:			
Labor and subsistence	....	219.38	
345 pieces 4 by 6 inches by 15 and 16 feet pine lumber = 11,040 feet B. M	19.657	217.02	
85 pieces 4 by 6 inches by 22 feet pine lumber = 3,740 feet B. M	20.44856	76.48	
100 pieces 6 by 6 inches by 26 feet pine lumber = 7,800 feet B. M	21.72488	169.45	
1,180 pounds $\frac{5}{8}$-inch square iron	.01921	22.67	
228 pounds 8 by $\frac{1}{2}$-inch spikes	.024	5.47	710.47
Lashing 653 linear feet of dike:			
Labor and subsistence	....	33.08	
3,190 linear feet $\frac{3}{8}$-inch wire cable	.011832	37.74	70.82
Cost of 895 linear feet triple-row dike	....	....	6,684.06

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Résumé of cost of dike construction in First Reach.

Group I:		
1,244 linear feet single-row dike	$1,642.54	
3,472 linear feet double-row dike	7,678.39	
4,760 linear feet triple-row dike	27,606.81	
Leveling sand bar to operate Cram hammer	218.32	
Moving Cram hammer to and from dikes	674.87	
Net cost	37,820.93	
Administration	1,153.67	
Office and miscellaneous expenses	2,008.44	
Current care of plant in service	1,337.73	
Rope and other supplies	644.12	
Services of steamers *Melusina*, *Sabrina*, and *Doris*	2,129.06	
Service of towboat *Wm. Stone*	10,276.05	
Total		$55,370.00
Group II:		
165 linear feet double-row dike	909.25	
1,400 linear feet triple-row dike	8,397.93	
Net cost	9,307.18	
Administration	283.91	
Office and miscellaneous expenses	494.20	
Current care of plant in service	329.18	
Rope and other supplies	158.52	
Service of steamers *Melusina*, *Sabrina*, and *Doris*	523.93	
Service of towboat *Wm. Stone*	2,528.81	
Total		13,625.73
Group III:		
120 linear feet double-row dike	796.66	
4,001 linear feet triple-row dike	20,021.45	
Net cost	20,818.11	
Administration	635.04	
Office and miscellaneous expenses	1,105.52	
Current care of plant in service	736.34	
Rope and other supplies	354.56	
Service of steamers *Melusina*, *Sabrina*, and *Doris*	1,171.86	
Service of towboat *Wm. Stone*	5,656.36	
Total		30,477.79
Cedar Island group:		
389 linear feet double-row dike	1,420.32	
895 linear feet triple-row dike	6,684.06	
Net cost	8,104.38	
Administration	247.22	
Office and miscellaneous expenses	430.32	
Current care of plant in service	286.67	
Rope and other supplies	138.02	
Service of steamers *Melusina*, *Sabrina*, and *Doris*	456.25	
Service of towboat *Wm. Stone*	2,201.98	
Total		11,864.84
Total cost of dike construction in First Reach		111,338.36

Results of improvement works.—The following results have thus far been accomplished by the dikes in First Reach, viz: In Group I the proposed channel section has been deepened between the Moreau River and the "towhead," and the left-hand chute at the "towhead" closed below a stage of about 115 feet. As a direct consequence of this latter change, the direction of flow has been diverted into the right-hand chute at the "towhead."

The dikes in Group II have caused the channel section in the right-hand chute to deepen about 25 per cent, and, in connection with the dikes in the first group, have caused the chute to widen by the erosion of the "towhead" to about 1,000 feet, as proposed in the project.

The dikes in Group III have also had the effect of deepening the channel, although not to the same extent as has been produced by the dikes of Groups I and II.

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The dikes at the head of Cedar Island are not of sufficient extent to have made any decided improvement.

The areas of sections between dikes, as a rule, have been greatly reduced by the formation of accretions, which, in some instances, are higher than the dikes through whose agency they were formed. This is the case below Dikes 2 and 3, and between Dikes 9 and 10. The areas of the sections sounded between the dikes convey a more correct idea of the extent of the accretions than those of the sections on the lines of the dikes, as the tops of the accretions are usually much higher on the former than on the latter. As the sounding of these intermediate sections was not begun until last spring, the areas of the accretions on their lines, shown in the table of areas of cross sections, etc., given below, do not include the amount of fill that occurred prior to that time. This fill was considerable in Group I.

The table of areas and the plotted sections on Plates VI, VII, and VIII indicate, in detail, the results of the improvement.

The sections designated in the table Dike 1, 2, 3, 9, 10, 13, 13b, and 14 were sounded on the lines of the dikes; those marked Dike 1′, 9′, 10′, 13a′, and 13b′ were taken about half way between the dikes.

Section Dike 3′ is 100 feet below Dike 3, and Section Dike 11′, 170 feet below Dike 11.

Sections were sounded on Dikes 2, 11, and 13*a*, but, as they only cover a short period, they have little value, and are omitted from the table.

In cases where the dikes have not been extended to the proposed lines of rectification, *e. g.*, in Group II, the areas in the column headed "areas between lines of rectification" are those included between the stream ends of the dikes and the opposite bank or line of rectification up to standard high water.

It is also to be noted that the total areas given in the table are not for the whole river, except at Group I.

The total areas for Group II do not include the areas of the left-hand chute at the "towhead." In Group III the area of Harlan Chute is omitted.

Areas of cross sections of the Missouri River in the vicinity of the dikes constructed in First Reach, from soundings made during the fiscal year ending June 30, 1892; also areas of scour and fill resulting from the dikes.

Section.	Date.	Gauge.	Areas below standard high-water = 122 feet.			Fill or scour behind dikes.		Fill or scour between lines of rectification.	
			Behind dikes.	Between lines of rectification.	Total.	Since last date.	Total.	Since last date.	Total.
		Feet.	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*
Dike 1	June 5, 1891	118.10	25,912	23,463	49,375	....	....	....	....
Do	May 6, 1892	119.00	21,920	25,043	46,963	+ 3,992	+ 3,992	— 1,580	— 1,580
Dike 1′	Mar. 23, 1892	112.05	23,654	27,182	50,836	....	....	....	....
Do	Apr. 2, 1892	116.30	23,095	21,571	44,666	+ 559	+ 559	+ 5,611	+ 5,611
Do	Apr. 18, 1892	118.10	19,764	26,898	46,662	+ 3,331	+ 3,890	— 5,327	+ 284
Do	May 4, 1892	114.90	19,055	29,885	48,940	+ 709	+ 4,599	— 2,987	— 2,703
Do	May 6, 1892	119.00	17,202	29,172	46,374	+ 1,853	+ 6,452	+ 713	— 1,990
Do	May 16, 1892	126.00	26,270	29,250	55,520	— 9,068	— 2,616	— 78	— 2,068
Do	May 26, 1892	121.95	23,724	27,211	50,935	+ 2,546	— 70	+ 2,039	— 29
Do	June 8, 1892	119.45	21,065	30,436	51,501	+ 2,659	+ 2,589	— 3,225	— 3,254
Do	June 15, 1892	117.45	21,409	30,968	52,377	— 344	+ 2,245	— 532	— 3,786
Dike 2	June 5, 1891	118.10	38,235	22,005	60,240	....	....	....	....
Do	May 6, 1892	119.00	22,927	30,731	53,658	+15,308	+15,308	— 8,726	— 8,726
Dike 3	June 5, 1891	118.10	31,047	19,829	50,876	....	....	....	....
Do	May 6, 1892	119.00	32,370	26,800	59,170	— 1,323	— 1,323	— 6,971	— 6,971
Dike 3′	May 19, 1892	124.00	27,235	25,000	52,235	....	....	....	....
Do	May 26, 1892	121.95	24,710	26,800	51,510	+ 2,525	+ 2,525	— 1,800	— 1,800
Do	June 10, 1892	117.80	19,356	28,598	47,954	+ 5,354	+ 7,879	— 1,798	— 3,598
Do	June 15, 1892	117.45	18,149	28,677	46,826	+ 1,207	+ 9,086	— 79	— 3,677
Dike 9	June 1, 1891	115.10	5,564	14,265	19,829	....	....	....	....
Do	Apr. 25, 1892	117.25	4,977	23,542	28,519	+ 587	+ 587	— 9,277	— 9,277
Dike 9′	Mar. 1, 1892	112.25	7,110	17,380	24,490	....	....	....	....
Do	Mar. 19, 1892	112.00	6,320	18,802	25,122	+ 790	+ 790	— 1,422	— 1,422
Do	Apr. 25, 1892	117.25	5,372	21,330	26,702	+ 948	+ 1,738	— 2,528	— 3,950
Do	May 7, 1892	120.10	4,898	21,484	26,382	+ 474	+ 2,212	— 154	— 4,104
Do	May 16, 1892	125.80	5,135	25,596	30,731	— 237	+ 1,975	— 4,112	— 8,216
Do	May 26, 1892	121.95	6,320	27,492	33,812	— 1,185	+ 790	— 1,896	—10,112
Do	June 8, 1892	119.45	4,187	30,045	34,232	+ 2,133	+ 2,923	— 2,553	—12,665
Do	June 16, 1892	117.35	4,424	28,598	33,022	— 237	+ 2,686	+ 1,447	—11,218
Dike 10	May 30, 1891	115.10	9,166	11,611	20,777	....	....	....	....
Do	Apr. 25, 1892	117.25	8,690	21,804	30,494	+ 476	+ 476	—10,193	—10,193
Dike 10′	Mar. 1, 1892	112.25	9,999	18,445	28,444	....	....	....	....
Do	Apr. 2, 1892	116.76	7,573	19,387	26,960	+ 2,426	+ 2,426	— 942	— 942
Do	Apr. 25, 1892	117.25	7,269	21,552	28,821	+ 304	+ 2,730	— 2,165	— 3,107
Do	May 4, 1892	114.90	7,189	22,200	29,389	+ 80	+ 2,810	— 648	— 3,755
Do	May 7, 1892	120.15	6,873	22,276	29,151	+ 316	+ 3,126	— 78	— 3,833

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Areas of cross sections of the Missouri River in the vicinity of the dikes constructed in First Reach, etc.—Continued.

Section.	Date.	Gauge.	Areas below standard high-water = 122 feet.			Fill or scour behind dikes.		Fill or scour between lines of rectification.	
			Behind dikes.	Between lines of rectification.	Total.	Since last date.	Total.	Since last date.	Total.
		Feet.	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*	*Sq. feet.*
Dike 10′	May 16, 1892	125.80	6,557	24,648	31,205	+ 316	+ 3,442	— 2,370	— 6,203
Do	May 26, 1892	121.95	6,715	24,885	31,600	— 158	+ 3,284	— 237	— 6,440
Do	June 8, 1892	119.40	6,685	26,634	33,319	+ 30	+ 3,314	— 1,749	— 8,189
Do	June 16, 1892	117.35	5,609	27,650	33,259	+ 1,076	+ 4,390	— 1,016	— 9,205
Dike 11′	Mar. 1, 1892	112.25	10,428	22,664	33,092	....	....	....	....
Do	May 16, 1892	125.80	11,060	26,133	37,193	— 632	— 632	— 3,469	— 3,469
Do	May 26, 1892	121.95	10,507	28,071	37,578	+ 553	— 79	— 1,938	— 5,407
Do	June 8, 1892	119.45	12,245	27,255	39,500	— 1,738	— 1,817	+ 816	— 4,591
Dike 13......	June 4, 1891	118.60	14,931	25,991	40,922	....	....	....	....
Do	June 9, 1892	118.50	14,852	30,020	44,872	+ 79	+ 79	— 4,029	— 4,029
Dike 13′	Apr. 9, 1892	118.50	10,586	28,756	39,342	....	....	....	....
Do	Apr. 20, 1892	118.10	9,875	27,650	37,525	+ 711	+ 711	+ 1,106	+ 1,106
Do	Mar. 18, 1892	112.35	11,949	25,400	37,349	— 2,074	— 1,363	+ 2,250	+ 3,356
Do	May 7, 1892	120.10	9,085	26,939	36,024	+ 2,864	+ 1,501	— 1,539	+ 1,817
Do	May 17, 1892	125.55	12,825	28,687	41,512	— 3,740	— 2,239	— 1,748	+ 69
Do	May 26, 1892	121.95	12,561	31,758	44,319	+ 264	— 1,975	— 3,071	— 8,002
Do	June 9, 1892	118.50	8,906	29,724	38,630	+ 3,655	+ 1,680	+ 2,034	— 968
Dike 13*a*′	Apr. 9, 1892	118.50	12,482	25,754	38,236	....	....	....	....
Do	Apr. 20, 1892	118.10	11,850	24,806	36,656	+ 632	+ 632	+ 948	+ 948
Do	Mar. 18, 1892	112.35	13,983	22,910	36,893	— 2,133	— 1,501	+ 1,896	+ 2,844
Do	May 7, 1892	120.10	12,861	25,754	38,615	+ 1,122	— 379	— 2,844	0
Do	May 17, 1892	125.55	15,958	26,228	42,186	— 3,097	— 3,476	— 474	— 474
Do	May 26, 1892	121.95	16,985	27,492	44,477	— 1,027	— 4,503	— 1,264	— 1,738
Do	June 9, 1892	118.50	15,168	27,650	42,818	+ 1,817	— 2,686	— 158	— 1,896
Dike 13*b*	Aug. 22, 1891	116.75	18,170	26,386	44,556	....	....	....	....
Do	June 9, 1892	118.50	17,380	27,413	44,793	+ 790	+ 790	— 1,027	— 1,027
Dike 13*b*′	Mar. 18, 1892	112.35	14,848	23,567	38,415	....	....	....	....
Do	Apr. 20, 1892	118.10	12,251	25,517	37,768	+ 2,597	+ 2,597	— 1,950	— 1,950
Do	May 7, 1892	120.10	10,290	25,591	35,881	+ 1,961	+ 4,558	— 74	— 2,024
Do	May 17, 1892	125.55	13,523	27,295	40,818	— 3,233	+ 1,325	— 1,704	— 3,728
Do	May 26, 1892	121.95	13,353	29,278	42,631	+ 170	+ 1,495	— 1,983	— 5,711
Do	June 9, 1892	118.50	11,534	28,677	40,211	+ 1,819	+ 3,314	+ 601	— 5,110
Do	June 16, 1892	117.35	9,875	27,413	37,288	+ 1,659	+ 4,973	+ 1,264	— 3,846
Dike 14......	June 4, 1891	118.60	17,380	21,014	38,394	....	....	....	....
Do	Feb. 29, 1892	113.00	17,301	21,804	39,105	+ 79	+ 79	— 790	— 790
Do	Mar. 17, 1892	113.00	17,380	23,226	40,606	— 79	0	— 1,422	— 2,212
Do	Apr. 20, 1892	118.10	11,850	25,596	37,446	+ 5,530	+ 5,530	— 2,370	— 4,582
Do	May 9, 1892	120.00	12,877	24,253	37,130	— 1,027	+ 4,503	+ 1,343	— 3,239
Do	May 17, 1892	125.55	14,615	26,465	41,080	— 1,738	+ 2,765	— 2,212	— 5,451
Do	May 26, 1892	121.95	15,879	29,151	45,030	— 1,264	+ 1,501	— 2,686	— 8,137
Do	June 9, 1892	118.50	16,748	28,440	45,188	— 869	+ 632	+ 711	— 7,426
Do	June 14, 1892	117.35	14,378	28,045	42,423	+ 2,370	+ 3,002	+ 395	— 7,031

The following table has been compiled from the preceding one, so as to make a clearer presentation of the changes wrought in channel rectification:

Section.	Period of observation.		Increase in channel area.	Remarks.
	From—	To—		
			Per cent.	
Dike 1	June 5, 1891	May 6, 1892	6.7	By deepening channel.
Dike 1′	Mar. 23, 1892	June 15, 1892	13.9	Do.
Dike 2	June 5, 1891	May 6, 1892	39.7	Do.
Dike 3	....do	....do	35	Do.
Dike 3′	May 19, 1892	June 15, 1892	14.7	Do.
Dike 9	June 1, 1891	Apr. 25, 1892	65	By deepening channel, 24 per cent; by erosion of towhead, 41 per cent.
Dike 9′	Mar. 1, 1892	June 16, 1892	65	By deepening channel, 27 per cent; by erosion of towhead, 38 per cent.
Dike 10	May 30, 1891	Apr. 25, 1892	88	By deepening channel, 53 per cent; by erosion of towhead, 35 per cent.
Dike 10′ ...	Mar. 1, 1892	June 16, 1892	50	By deepening channel, 27 per cent; by erosion of towhead, 23 per cent.
Dike 11′ ...	....do	June 8, 1892	20.3	By deepening channel, 20.3 per cent; by erosion of towhead, none.
Dike 13	June 4, 1891	June 9, 1892	15.5	By deepening channel.
Dike 13′	Apr. 9, 1892	....do	3.7	Do.
Dike 13*a*′ ..	....do	....do	7.4	Do.
Dike 13*b* ...	Aug. 22, 1891	....do	3.9	Do.
Dike 13*b*′ ..	Mar. 18, 1892	June 16, 1892	16.3	Do.
Dike 14	June 4, 1891	June 14, 1892	33.5	Do.

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The discharge measurements made in the right-hand chute at the "towhead" during the progress of the work are platted on Plate x. These observations show, by the changes in volume of discharge, the rate at which the area of the chute enlarged. They also furnish an interesting illustration of the effect of the improvement on the relation between gauge and volume of discharge.

Construction materials.—The materials used for dike construction in the First Reach were purchased in open market, excepting the willow brush, which was procured by hired labor at different points on the river between Burlington, Mo., and Hermann, Mo. Its cost is greater than in former years on other works, on account of the rehandling and long hauls made necessary by having to get it to the first group of dikes for the winter work.

The cottonwood piles were purchased, delivered on barges, at different points along the river between the mouth of Grand River and Ewings Landing, or delivered in rafts at the latter point. The latter method of delivery was very unsatisfactory, as the piles had to be taken out of the water and placed on barges, which was troublesome and expensive.

A portion of the cottonwood piles were ordered with bark removed, so as to test, if possible, the lasting qualities of the piles under this condition, and to determine if it was worth while incurring the extra expense of removing the bark.

Arrangements were made in the winter of 1891–'92 to procure a supply of native-oak piles for spring work. These piles are of the different varieties of oak found in this section, *i. e.*, water oak, red oak, black oak, and white oak. The greater number of them were procured within 25 miles of the work, and were delivered loaded on barges, or on the river bank at regular steamboat landings.

The white-oak piles were purchased delivered on the river bank at Jefferson City, Mo., and at Bonnots Mill, Missouri.

The lumber used for bracing the dikes is yellow pine, from the Southern States west of the Mississippi River. It was delivered on the railroad track at Osage City, Mo., and Jefferson City, Mo.

About 348,000 feet, B. M., of the lumber was stored on the river bank just above Barkersville, so as to be convenient for work in the early spring. During the rise in May the bank was overflowed where the lumber was stored, and 230,000 feet, B. M., of it had to be loaded on barges.

The quantities and cost of the principal materials used for dike construction during the fiscal year ending June 30, 1892, are given in the following table.

The cost per unit is the average cost, and includes the purchase price and all expenses of handling in unloading from cars, loading and unloading barges, and hauling to the dike in the first group, but not of towboat service.

Materials.	Quantity procured.	Quantity used for dike work.	Cost per unit.
Willow brush.....cords..	5, 133. 15	4, 285. 50	$2. 65622
Stone.....cubic yards..	5, 866. 91	4, 890. 26	1. 02348
Cottonwood piles.....linear feet..	170. 312. 00	138, 263. 00	. 095805
Native-oak piles.....do....	85, 524. 00	31, 357. 00	. 11148
White-oak piles.....do....	38, 494. 00	18, 654. 00	. 16951
Yellow-pine lumber:			
4 by 6 inches by 15 feet and 4 by 6 inches by 16 feet, feet, B. M.....	425, 650. 00	194, 950. 00	19. 65700
4 by 6 inches by 12 feet.....feet, B. M..	10, 776. 00	8, 864. 00	18. 93653
4 by 6 inches by 22 feet.....do....	148, 676, 00	72, 292. 00	20. 44856
6 by 6 inches by 26 feet.....do....	243, 750. 00	131, 040. 00	21. 72488
6 by 8 inches by 26 feet.....do....	34, 528. 00	8, 528. 00	24. 83636
4 by 4 inches by 17 feet.....do....	41, 888. 00	4, 103. 00	19. 98090
⅝-inch wire cable.....feet..	270, 800. 00	98, 000. 00	. 011832
⅜-inch iron.....pounds..	48, 310. 00	31, 500. 00	. 019210

TOW-BOAT SERVICE.

The towboats *Wm. Stone* and *Alert*, also the steamers *Melusina*, *Sabrina*, and *Doris*, were used at different times during the progress of the work, for moving plant and transporting materials. The *Alert* was used in the early part of July for moving plant from Kansas City and Miami to the First Reach. The boat was transferred to the St. Joseph Division in the early part of July, and did not return to Kansas City until October 5. She was then employed moving plant from Kansas City to Ewings Landing until the latter part of November, when she had to be laid up for the winter at Boonville, on account of extreme low water making navigation impossible.

The plant moved by the *Alert* from Kansas City to Ewings in October and November consisted of one construction quarter boat, two hydraulic graders, two pile sink-

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ers, one mattress boat, one 100-foot barge, one 64-foot barge, and one brush quarter boat; also three barges of piling from Grand River. She was put in commission again, in the early part of March, to bring eight 100-foot barges from St. Joseph, one 100-foot barge from Grand River, and one 100-foot and one 64-foot barge from Cogswells Landing. The three barges were left at the points named, while in tow of the *Alert* and *Melusina*, in November, on account of the extreme low stage of water.

The service required of the *Alert* was completed April 22, when she was sent out of the river, to be laid up at Bushberg, Mo.

The towboat *Wm. Stone* was employed in the early part of July in moving plant from Miami to Ewings, after which service the boat was used for moving floating plant from one part of the work to another, or in making long tows after materials. On account of the extreme low stage of water in the fall it was not considered safe for the boat to attempt to get to Bushberg, Mo., and she was laid up below Dike 11 at Ewings Landing, December 12.

The boat was put in commission again about the latter part of February, and rendered the same class of service as in the fall. She also made a trip to Bushberg, Mo., in the latter part of March, for coal and two small quarter boats, and another trip to St. Louis, Mo., in June, to get plant material and coal. The boat's crew was reduced in the latter part of May, on account of active operations being suspended.

The *Melusina* was used in November to assist in bringing plant from Kansas City to Ewings. She was laid up in December. The boat was put in commission again about February 20, and was used for moving plant and transporting materials for dike work until operations were suspended in May. After May 14, the *Melusina* was used by the observation party in sounding cross sections and measuring discharges of the river.

The *Sabrina* was transferred from the St. Joseph division to the First Reach April 21, and arrived at Ewings April 26. The boat was employed in moving plant and materials for dike construction until the latter part of May. The crew was then laid off and the boat tied up.

The *Doris* had been unserviceable since 1890 on account of the condition of her hull; but as it was almost impossible to proceed with dike construction without a small steamboat, and, as there was no other boat available, her hull was repaired, and the boat put in service September 8.

The *Doris* was sunk September 29 by staving a hole in her bottom against a snag in dead water, behind Dike 13*a*. She was raised and repaired by October 10, and rendered valuable service the remainder of the season. She was put in commission after the river opened, but was sunk a second time on February 4 by staving a hole in her bottom. The boat was raised with considerable difficulty and laid up, as it was unsafe to use her further without a new hull.

The total cost of service rendered by the towboats *Wm. Stone* and *Alert* amounts to $36,037.07, and of the steamers *Melusina, Sabrina,* and *Doris* to $5,727.75, or a total of $41,764.82.

PLANT.

By the close of the last fiscal year all the plant, excepting that required for carrying on the work at Kansas City, Mo., had been assembled at Ewings Landing. In October and November the Kansas City plant, with the exception of three barges, which were left at Cogswells Landing and Grand River, was brought to First Reach by the *Alert* and *Melusina*.

In March and April the three barges and eight other 100-foot barges were brought from St. Joseph, Mo., by the *Alert* and *Sabrina*.

Arrangements were made in September for establishing a boat yard and constructing a set of ways and tracks at Ewings Landing, with sufficient capacity for storing all the floating plant. As only a part of the lumber ordered for the ways and tracks was furnished by the time agreed on, they could not be constructed as large as designed, and, in consequence, two mattress boats, fourteen 100-foot barges, two 64-foot barges, and the unserviceable steamer *Doris* had to be left in the river under Dikes 9 and 11.

The remainder of the plant at Ewings Landing, consisting of one machine-boat, two construction quarter boats, eight pile-sinkers and cross boats, three hydraulic graders, nine 100-foot barges, seven small barges with quarters, and the steamer *Melusina*, were pulled out on the ways. The launching of the boats and repairs to their hulls were begun February 15, and completed April 5.

Very extensive repairs had to be made to all the hulls during the year, as a great deal of timber which was not removed when the plant was repaired at Kansas City, Mo., in 1889, on account of being in good condition, had become defective.

Three of the pile-sinkers were fitted with six sets of leads, and the steam winches on all the sinkers thoroughly overhauled and repaired.

The unserviceable Blake steam pump on Hydraulic Grader No. 5 was removed, the

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boat strengthened by hog chains, and the Cram steam hammer and leads erected on it.

The steamer *Doris* was raised, after being sunk in September, and her hull repaired. After being sunk a second time, she was raised, her boilers and engine removed, and her machinery put in order to be used in a new hull.

The new plant purchased during the year consisted of a Cram steam hammer, with engine, boiler, and leads; also mess utensils, carpenters' and machinists' tools, and rope for the tackle in hauling out the boats on the ways.

A telephone line was erected to connect the boat yard with Jefferson City, Mo.

The following statement shows the expenditures made on account of care and repair of plant, moving plant, and new plant purchased.

Statement of expenditures on account of plant.

Moving plant to First Reach from Kansas City, St. Joseph, and Bushberg:		
Steamboat service	$14,380.52	
Labor, handling plant material	931.03	
		$15,311.55
Care of plant:		
Watching, cutting ice and clearing out drift from boats, and other labor	7,894.13	
Towboat service	1,800.00	
Supplies, oils, paints, etc	276.00	
Constructing ways and tracks	6,377.27	
Erecting temporary buildings, fences, etc	1,001.67	
Laying up fleet on ways	1,219.19	
Launching fleet	1,332.81	
Administration and miscellaneous expenses	1,663.80	
		21,564.87
Repairs to plant:		
Carpenters, machinists, and unskilled labor	21,190.83	
Lumber, nails, iron, coal, paint, oils, etc	6,616.44	
Administration and miscellaneous expenses	2,324.91	
		30,132.18
New plant:		
Cram steam hammer, boiler, engine, leads, and labor of erecting	2,251.38	
Telephone line	437.24	
Tools, rope, oars, mess utensils, etc	2,843.72	
Labor	95.70	
		5,628.04
Total		72,636.64

SURVEY AND OBSERVATION PARTY.

In addition to the duties already described as having been performed by the survey party, the elevations and measurements required for dike construction were made by it; also special surveys of the lands situated on Dodds Island and between the mouth of the Osage River and Fergusons Landing.

The total cost of survey work, observations for discharge, cross-section work, and borings, including the computing of field notes, making maps and tracings, amounts to $9,199.

The gauges between Fort Leavenworth, Kans., and St. Charles, Mo., were inspected and tested by members of the survey party in July, August, September, October, December, and March.

In conducting the operations above described, I have been assisted in constructing improvement works by Assistants R. H. Bacot and A. H. Weber; on shore-line and hydrographic surveys by Assistant R. A. Crawford; and in making out pay rolls and accounts by Mr. Morris Rosenbach.

Very respectfully, your obedient servant,

SAMUEL H. YONGE,
Division Engineer.

Lieut. Col. CHAS. R. SUTER,
Corps of Engineers, U. S. A.,
President Missouri River Commission.

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APPENDIX Y Y.

BRIDGING NAVIGABLE WATERS OF THE UNITED STATES.

1. Report of Board of Engineers on proposed bridge of city of Duluth, Minnesota, across canal at entrance of Duluth Harbor.
2. Report of Board of Engineers on proposed bridges of city of Portland, Oregon, across Willamette River at Burnside and Knight-Quimby streets.

Y Y 1.

REPORT OF BOARD OF ENGINEERS ON PROPOSED BRIDGE OF CITY OF DULUTH, MINNESOTA, ACROSS CANAL AT ENTRANCE OF DULUTH HARBOR.

[Printed in Senate Ex. Doc. No. 80, Fifty-second Congress, first session.]

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., April 6, 1892.

GENERAL: By Special Orders No. 6, Headquarters, Corps of Engineers, February 1, 1892, a Board of Engineers was constituted to assemble at Detroit, Mich., upon the call of the senior member, "to examine and report upon the plans of a bridge over the entrance to Duluth Harbor, on Lake street, submitted by the board of public works of the city of Duluth, Minn."

Under date of February 1, 1892, the Board were instructed to give careful consideration to the subject, and to advertise for twenty days in two daily papers (six insertions in each paper) published in each of the cities of Buffalo, N. Y.; Cleveland, Ohio; Detroit, Mich.; Chicago, Ill., and Milwaukee, Wis., the fact that a hearing will be had upon a proposed bridge over the canal at Duluth; the day of meeting of the Board to be announced in the advertisement.

Under date of February 29, 1892, the Board were further instructed—

That it was not intended that the duties of the Board should be limited to the consideration of the plans submitted by the board of public works of the city of Duluth, Minn., alone, but that the Board should consider and report upon the advisability of permitting the construction of any bridge over the harbor entrance.

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In obedience to the instructions first cited, the following advertisement was published as directed:

UNITED STATES ENGINEER OFFICE.
Duluth, Minn.

Application has been made to the Secretary of War by the municipal authorities of the city of Duluth, Minn., for permission to bridge the canal at the entrance of the harbor at that place, and a public meeting to consider such arguments as may be advanced for and against granting the permission sought will be held at the United States Engineer office, 34 West Congress street, Detroit, Mich., beginning at 10 a. m., March 21, 1892. All persons interested are invited to be present, and an opportunity will be given to all who desire to be heard. It is requested that arguments be reduced to writing and presented in duplicate, either in person or by mail.

W. L. FISK.
Captain, Corps of Engineers.

The Board assembled accordingly at the United States Engineer office, 34 West Congress street, Detroit, Mich., at 10 a. m., March 21, 1892, and devoted the remainder of that day and the whole of the two days next succeeding to a public hearing of all parties desiring to present their views upon the subject, at the same time encouraging such opposition to each speaker as would tend to elicit all the facts and theories relating to the case. Every endeavor was made, both by the advertisement and during the course of the public sessions of the Board, to secure a proper presentation of the arguments for and against the proposition to bridge the canal in question, and it is believed that this was accomplished to the satisfaction of all concerned, and that all desiring to do so had the fullest opportunity to be heard and to controvert opposing views.

The substance of the oral discussions, especially those presented by the persons favoring the bridge, was reduced to writing, and this, with all written briefs in the case, is transmitted with this report. It is to be regretted that the oral arguments made in the interest of those opposing the bridge were not stenographically reported, to the end that they might be referred to at any time.

The following is a summary of arguments submitted by those who favored the construction of the proposed bridge, viz:

The people of Duluth are interested to a greater degree than anybody else in having an unobstructed harbor entrance, and therefore do not desire to do anything which would be likely to injuriously affect it. The territory of Minnesota Point is imperatively necessary to the city for business purposes. Manufacturing, wharfage, and railroad terminal facilities thereon can only be utilized through a ready means of communication; and, for these, under present conditions, none but a bridge is practicable. An enormously valuable property is rendered useless through this lack of suitable communication with the mainland.

It is asserted that railroads desire to obtain terminal facilities at Duluth which the city can not give except on Minnesota Point, the inside face of which affords the best dock frontage in the harbor.

The land occupied by the canal belongs partly to the city and partly to individuals.

The State of Minnesota has power to authorize the bridge over the canal, and has granted such authority to the city of Duluth. The city waives its rights, and submits to the authority of the United States in the premises.

A denial of the privilege would deprive the city of Duluth of 20 miles of the dock frontage.

Vessels, in getting to existing docks, are required to take a tortuous course up bay and river through two bridges, with others in prospect.

Shipping business is now scattered over too much territory.

The area of ground on the immediate city front now available for docks and railroad terminals is extremely small.

It is denied that politics or real estate speculation influences Duluth in this matter.

It is denied that the bridge proposed would obstruct navigation.

The allegations of fact in the statement of Capt. McDougall are denied or explained.

The shipments of wheat have amounted to $35,000,000 in one year.

Iron mines of fabulous extent and value are tributary to this port. The aggre-

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gate of moneyed interests requiring better docking and shipping facilities is over $700,000,000.

It is claimed that vessels entering the canal could be notified in ample time, in case anything prevented the operation of the proposed bridge.

In clear weather vessels could be sighted from the bridge when 20 miles distant, and fogs are not accompanied by wind.

Even in violent storms, they have never known vessels to have any considerable difficulty in passing through the canal.

The anchorage outside the canal is good, and would be available in case of trouble with the bridge; or vessels could make the harbor through the channel at the southern end of Minnesota Point.

Denied that there is plenty of room for docks, centrally located, elsewhere than on Minnesota Point.

Claimed that the combination of circumstances required to prevent a vessel passing through the canal after the construction of the bridge would be extraordinary, and thus far unheard of.

The city of Duluth will agree to erect this bridge after navigation closes, thoroughly test its operation before navigation again opens, and to remove it in case the slightest hindrance to its operation should appear.

Directly in front of Duluth, but cut off by the canal from all commercial intercourse, lies a suitable territory of sufficient area to accommodate a population of 100,000 people, having ideal conditions for establishing 20 miles or more of dock frontage. Duluth needs and must have a greater area of level territory, more dock room centrally located, more railroad terminal grounds. She can get it on Minnesota Point and nowhere else.

A tunnel under the canal would cost not less than $500,000, and would probably cost twice that sum or more. The proposed bridge could be built for $150,000; Duluth could raise the latter sum, but not the former.

A street railway is now established on Minnesota Point. It accommodates the regular residents, as well as campers and tourists. It has no connection with Duluth, and a connection should be established by the construction of a bridge.

It is cited that Chicago, with a population of 1,100,000, had 22,000 arrivals and clearances last year, as against 3,600 at Duluth with a population of 50,000; and yet Chicago was able to transact its business, notwithstanding the fact that its river is spanned by more than 20 bridges.

Owing to increase in size of vessels, the number of arrivals and departures will not increase in ratio with the tonnage.

It was admitted during the oral discussion that in a few years, say five, the traffic across the bridge might become so great as to make it impossible to accomodate it without unreasonably obstructing the canal. In that event, it was stated, Duluth would make a tunnel, but can not raise the money to do so now.

It was claimed that if Duluth were required to build a bridge so perfect as to be absolutely free from liability to derangement through human defects in design, construction, or operation, the city would be subjected to a rule which would stop all human progress. Further, that everything done by man is attended by more or less risk, and it would therefore be unfair to insist upon absolute perfection in a device for passing traffic across the canal.

It is submitted that in designing this bridge Duluth, regardless of cost, has invoked the resources of the ablest engineers to provide all the safeguards which human foresight can devise, and that it is neither just nor fair to demand more. She protests that her progress should not be stopped for lack of a surety that would be superhuman.

Duluth would be the last to place a serious obstruction across the entrance to her harbor. She only seeks a way, within her financial ability, to utilize her rightful territory.

Duluth imperatively needs Minnesota Point as terminal grounds for new railroads. Several are now seeking such facilities. They do not exist except upon the land in question. If they can not get them at Duluth they must go elsewhere.

It is denied that any serious difficulty exists in entering Duluth Harbor in any sort of weather. It is claimed that vessels can always haul up outside and either lay to, cast anchor, or enter south of Minnesota Point.

It is claimed that serious danger to shipping could be threatened only in case the machinery of the bridge should fail to operate at a time when one or more vessels were approaching during a severe northeasterly gale, and that the chance of such a conjunction occurring, according to the theory of probabilities, would be only 1 to 2,800,000.

Duluth will agree to keep the bridge open at night during stormy weather; also in the daytime during unusual northeast storms. And in case the increase of shipping should be so considerable as to render the bridge an unreasonable obstruction, they would keep it open altogether during the season of navigation, and only use it as a

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bridge during the winter season, when there is no navigation. It was stated that the city would enter into bonds to guarantee these propositions. The city will also agree to adopt every practicable safeguard against accidents, including the best methods of signaling, and to remove the bridge immediately should it actually prove to be an unreasonable obstruction.

It is claimed that Duluth is the easiest port to enter in the world, no matter what the weather may be; and the record is cited to show that heretofore but trivial mishaps have occurred to vessels entering the harbor.

Opinions of well-known experts in bridge and elevator practice are submitted to the effect that beyond a reasonable doubt the proposed bridge could be operated without interruption.

The foregoing cover the principal points made by the advocates of the bridge project. In like manner the arguments of the opponents of the bridge may be briefed as follows:

It was asserted that, at present, there are only about 200 people on Minnesota Point, and that the land is not needed for dock frontage, there being a great abundance of room still unoccupied in Duluth and vicinity; that the scheme is advanced in the interest of speculators; that northeast storms, which usually occur late in the fall and are generally accompanied by snow, have a clear water sweep of 350 miles; that the lake shores converge so as to form a great funnel, the apex of which is the canal, up which the storms sweep with unobstructed force, creating very heavy seas at and through the canal, even to such extent as to sometimes prevent vessels from lying at the docks inside the harbor near the prolongation of the canal.

Several great storms and their severe effects are cited in detail, during which a breakwater and some vessels were wrecked. Actual experience of navigators is cited to prove the danger of this entrance in northeast gales. It is stated that during one storm the waves rolling through the canal made it impracticable to load vessels at the wharves of Duluth. It is further stated that waves in the canal were observed running as high as 12 feet above the canal piers and spreading out as far as 50 feet on each side, and the opinion is expressed that if they had encountered any obstruction on the banks of the canal the resulting spray would have been thrown to the height of 50 feet or more. In case of snow or freezing weather such obstructions would soon have been covered with ice.

It is asserted that currents of 6 or 7 miles per hour have been observed in the canal and their direction changed in half an hour.

A case is supposed of the east and west bound shipping being both caught in a severe gale and driven into Duluth Entrance coincident with a failure of the bridge machinery, and the disaster which would probably occur under these conditions is described.

Capt. McDougall asserts that in severe storms all vessels in the immediate vicinity must enter through the canal; that they can not enter south of Minnesota Point; that during the season of 1891 nearly 4,000,000 tons of freight passed through the canal, carried by more than 200 vessels, having an aggregate value exceeding $30,000,000.

It is claimed that under stress of weather vessels might get so close that they could not haul off in case of unlooked-for hindrance to the operation of a bridge; that Duluth is a difficult harbor to enter, and under certain conditions a very dangerous one.

It is stated that if the bridge traffic should be inconsiderable it would not be just to create an obstruction to accommodate it; while if it should prove to be considerable it could not be accommodated without blocking the canal traffic.

It is stated that Duluth can have easy and sufficient access to Minnesota Point (1) by a tunnel; (2) by a trestle bridge with a draw in it across the bay; (3) by means of a ferryboat. With these available, it is claimed to be unreasonable to insist upon reaching that territory by means of a dangerous obstruction at the very entrance to the harbor.

It is claimed that Duluth Harbor is difficult of entrance because, although narrow, a good speed must be maintained while passing through the canal. The difficulties increase with the size of the vessels, and these are rapidly increasing in size. That very large vessels can not be brought to a stop while passing the canal in strong easterly weather, and consequently the existence of any bridge over it would invite disaster.

It is predicted that this little canal is destined to become one of the world's great concentrating points of shipping; that this will result in a necessity for widening it considerably, and that the existence of a bridge over it would greatly retard, if not prevent, this work.

It is asserted that at the bottom of this great funnel at Duluth the storm effects are worse than at any other place on the lakes.

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To the arguments presented for and against the bridge by the opposing interests, the Board submit the following description and facts of record.

At its western extremity the shores of Lake Superior converge under a sharp angle, near the apex of which lie the harbors of Duluth and Superior City. At a point in the angle where the opening is about 9 miles wide a low sand point extends across and incloses a great natural harbor, the Bay of Superior. Only one natural break occurs in it, and here the waters of St. Louis and Nemadji rivers effect an outlet to the lake. This outlet is near the southern extremity. It has been utilized as a harbor entrance and the Government has built piers and otherwise expended considerable money to improve it.

Something less than a mile inside this natural breakwater, where the lake shore lines converge to an opening of about 5 miles, occurs another split lying substantially parallel to it. Here again the opening is nearest the southern end. It furnishes an outlet for the St. Louis River. The north end is called Rices Point, the south end Conners Point. The angular opening of the lake behind this spit is a large sheet of water called St. Louis Bay, the upper portion of which is the estuary of St. Louis River.

Superior and St. Louis bays are quite shallow, except where the waters of the St. Louis River form through them a narrow channel to the lake. Harbor room in either for large modern vessels has to be provided by dredging.

The exterior formation making out from the north shore is called Minnesota Point. It is about 6½ miles long. That proceeding from the south shore is called Wisconsin Point and is nearly 2½ miles long. The two have widths varying from 200 to 1,000 feet and rise but a few feet above the level of the lake.

Exterior to Minnesota Point the lake bottom falls rapidly away to considerable depths, especially in the angle at the north end. Along this point it is reported by the citizens of Duluth that vessels can safely ride at anchor in all conditions of weather. The physical conditions at this locality are such as to indicate that there might be times when such anchorage would be risky. A Lake Survey chart of 1861 shows, at the south end of Minnesota Point, a channel into Superior Bay with a least depth of 10 feet. This was prior to any improvement. An Engineer Department map of 1891 shows a least depth here of 16 feet; but the date of the soundings is not given.

The St. Louis River, in this locality, forms the boundary between the States of Minnesota and Wisconsin. On the south shore of the lake opening have sprung up the Wisconsin cities of Superior and West Superior, while on the north has been created the Minnesota city of Duluth. The rivalry between these cities is intense and bitter, to the extent that the discussion of anything affecting the entrance to the port behind Minnesota Point is very much disturbed by local issues.

In the fall of 1870 the city of Duluth began cutting a canal across Minnesota Point near its shore end for the purpose of effecting a quick entrance to her own harbor front. This proceeding developed great opposition on the part of Superior and the State of Wisconsin, on the ground that the waters of St. Louis River could not keep sufficient channels scoured through two outlets, and that the one at the south end of Minnesota Point, being the farthest away, would suffer. The contention resulted in the construction of a dike across Superior Bay from Minnesota Point to Rices Point, which cut off the waters of St.

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Louis River from an escape through the canal. The following extract from the Report of the Chief of Engineers for 1879 gives some of the subsequent history of this contention:

In the spring of 1871 an injunction was issued at the instance of the War Department, restraining further operations in prosecution of the canal. This was subsequently dissolved upon the execution by the city of Duluth of a bond for $100,000 to secure the construction of a dike extending from Minnesota Point to Rices Point, and isolating the harbor from the rest of the bay of Superior; said dike to be completed by December 1, 1871. Under this agreement work was resumed and the canal completed during the working season of 1871. It was 250 feet wide and lined with crib-work piers, which extended to deep water in the lake, where the opening widens to 290 feet. The time for the completion of the dike was extended, at the request of the authorities of Duluth, to March 15, 1872, at which date it was reported complete and offered for inspection to the United States authorities. Its construction was wholly unsuited to the requirements of such a work, being made of light crib-work ballasted with stone and filled with sand. It proved to be utterly inadequate. The filling was washed out and the crib work in parts floated out of place; in parts was crushed by ice. * * *

No action was taken on the bond, which was pronounced worthless by eminent lawyers, the city not having legal authority to execute the same.

Since the date of this report the dike has practically disappeared. The canal remains, having a length of about 1,300 feet. The distance from the outer end to Lake street, the proposed location of the bridge, is about 900 feet.

Starting from the northern shore of the lake, some 2,000 feet from the base of Minnesota Point, the United States built a breakwater which, in 1872, had reached a length of 1,200 feet. It was formed of cribs 30 feet wide by 50 feet long, and was provided with a decked superstructure to a height of 6 feet above the water level. Although built in the most substantial manner of such structures on the lakes, it was wrecked by a storm which occurred on November 14, 1872. But little of it now remains, and it has been abandoned.

The cause of this destructive action is to be readily found in the formation of the land on the northern shore of the lake in this vicinity. Rising to a height of about 700 feet above the lake level, it seems to direct easterly winds toward the location of the breakwater and the entrance of the canal, rolling the resulting seas, with accumulated force, in the same direction. It is easily conceivable that their force should prove almost irresistible by any structure less substantial than those built to withstand ocean storms. The destruction of this breakwater supports, to some extent, the assertions made by the opponents of the bridge concerning the extreme severity of the wind and wave action at this locality during unusual gales.

Duluth is, at this time, both a local harbor and a harbor of refuge. The distance to Two Harbors, the nearest shelter on the northern shore, is about 27 miles, and the distance to Bark Bay, the nearest shelter on the southern shore, is about 45 miles. Hence a vessel to leeward of these, with easterly wind, has no harbor available but Duluth, and, of necessity, must make it.

CONCLUSION.

The Board do not admit the extent of the dangers recited by the opponents of the bridge project, and fully recognize the great advantage to the city of Duluth which would accrue from suitable means of communication with Minnesota Point. The latter clearly appears to be a necessity to the future growth of the city, as well as to the com-

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merce which promises so soon to pour through her gates; and every foot of dock frontage behind that strip of land ought to be available. There ought to be considerable concession upon the part of each of the conflicting interests involved, and each should yield a fair measure.

The design of the lift bridge proposed is one of great merit, and the details seem to be well studied and arranged. Any objections to the plan which have appeared to the Board are of a minor character, and do not extend to the main proposition, because they can be readily obviated. A complete description of the bridge is to be found in the papers and drawings* submitted by Mr. J. A. L. Waddell, the engineer who designed it.

It is to be understood that these favorable remarks apply to the design and not to the question whether a lift bridge is to be preferred at this locality. As a matter of fact the Board think that a properly designed swing bridge would better fulfill the requirements, except as to the area of ground that would have to be occupied by the shore arm of the structure.

The city of Duluth states that she can afford to build the bridge proposed, but can not afford to construct a tunnel (which is admitted to be a complete solution of the problem), and that if she can not have a bridge she must be deprived of the use of Minnesota Point, the only direction in which the city can expand for commercial purposes. This is a strong argument and appeals to the sympathy of the Board, especially in view of the well-known activity and enterprise of the people of Duluth, which certainly deserve all the encouragement that can properly be extended. But the Board feel compelled to put this aside and to deal with the question regardless of sentiment. They must look to the future and base their opinion upon what seems to them best for the interests of all concerned.

In view of the facts and arguments detailed the Board concludes that it is not advisable to authorize the construction of any bridge across the canal entrance to the harbor of Duluth, Minn. They believe that the dangers and difficulties to shipping which would result from the bridge proposed have been overestimated by its opponents, while the degree of obstruction which would be due to such a structure has been underrated by its advocates. Any bridge over a waterway is a menace to navigation, but the propositions of the city of Duluth, if carried into effect, would reduce them to a minimum in this case.

The city of Duluth proposes certain guaranties looking to the proper operation of the bridge, and even to its removal in case it should prove to be an unreasonable obstruction. The probable value of such a guaranty is indicated in the closing paragraph from the Report of the Chief of Engineers heretofore quoted.

If there were a breakwater outside of and covering the entrance to the canal, such that vessels would approach and pass the canal free from danger due to stress of weather or perils of the sea, the conditions would differ so much from those actually existing that the Board might find it less difficult to reach a conclusion that would be satisfactory to Duluth.

One very important factor in leading the Board to their conclusion is their disinclination to establish a dangerous precedent. The piers which border the canal at Duluth are essentially the same in general function as those which are found at the entrance to the principal lake

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harbors, and the canal itself corresponds exactly with the throat of all harbors where the entrance is between piers. It is the point where the mariner passes from the perils of the sea into the shelter and safety of the harbor. He approaches this point, and sometimes passes it, in the midst of a struggle for life and property. Such a point can not be too free from obstruction, or the possibility of it. If a bridge were authorized over the canal at Duluth there could be no reasonable objection to permitting such a structure at any other exposed harbor entrance on the lakes; and without doubt applications for authority to bridge other harbor entrances would rapidly follow upon the granting of such privilege at Duluth, thus leading to a condition which would be unendurable.

Statements and arguments made to the Board have been largely reduced to writing by the parties presenting them, and are submitted herewith, as follows:*

(1) Description of the lift bridge, with drawings, by Mr. J. A. L. Waddell, engineer.
(2) Letter of Mr. Thomas E. Brown, consulting engineer, approving the plans of said bridge.
(3) Letter of Otis Brothers, makers of elevators and hoisting machinery.
(4) Letter of Mr. K. Bryan, chief engineer Hale Elevator Company, approving the bridge, in detail.
(5) Argument of Mr. Henry Truelsen, president board of public works, Duluth, Minn.
(6) Argument of the city council of Duluth, by Alderman Charles A. Long.
(7) Argument of S. L. Smith, esq., city attorney of Duluth.
(8) Oral argument (opening) of Mr. S. A. Thompson, representing the Chamber of Commerce, Duluth.
(9) Oral argument (closing) of same.
(10) Closing argument of Mr. Henry Truelsen, president board of public works, Duluth, Minn., and J. A. L. Waddell, consulting engineer.
(11) Argument of J. W. Miller, harbor master port of Duluth.
(12) Argument of Capt. Alexander McDougall.
(13) Argument of Vessel Owners' Association.
(14) Argument of Lake Carriers' Association by its delegates, W. Livingston, jr., James Davidson, Charles H. Keep.
(15) Telegraphic protest of vessel-owners of Buffalo, N. Y.
(16) Argument and protest of vessel-owners of Milwaukee, Wis.
(17) Protest of Joseph Austrian, of Chicago, Ill., manager Lake Michigan and Lake Superior Transportation Company.
(18) Request of F. C. H. Arntz and L. E. Sangdahl, of Milwaukee, Wis., that their plans for a bridge be considered.

There is also inclosed a map† of the harbor of Duluth, Minn.

All of which is respectfully submitted.

O. M. POE,
Colonel, Corps of Engineers.
WILLIAM LUDLOW,
Major, Corps of Engineers.
W. A. JONES,
Major, Corps of E[illegible]

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers.

*Not reprinted; printed in [illegible] session.
†Not printed.

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REPORT OF BOARD OF ENGINEERS ON PROPOSED BRIDGES OF CITY OF PORTLAND, OREGON, ACROSS WILLAMETTE RIVER AT BURNSIDE AND KNIGHT-QUIMBY STREETS.

[Printed in Senate Ex. Doc. No. 118, Fifty-second Congress, first session.]

PORTLAND, OREGON, *June 13, 1892.*

GENERAL: The Board of Engineer Officers convened by virtue of Special Orders No. 18, dated Headquarters, Corps of Engineers, U. S. Army, Washington, D. C., April 18, 1892, to which was referred for investigation and report the drawings for two bridges that the Portland bridge committee, a body organized and acting under authority of an act of the legislature of the State of Oregon, propose to build over the Willamette River within the limits of the city of Portland, and which had been submitted to the Secretary of War for his approval, as required by act of Congress approved September 19, 1890, has the honor to submit the following report:

The interests involved in the construction of these bridges are of so great importance to the city of Portland and the commerce of the State of Oregon, and there is such a diversity of opinion among the people of the community as to their location and the need or propriety of their erection, and the effect that they will have upon individual interests, and the general prosperity of the city is so great that the Board approaches the consideration of the subject with a realizing sense of the responsibility resting on it. In order that a clear understanding may be had of the question, a brief description of some of the considerations involved is thought to be necessary.

The city of Portland is located upon the Willamette River, about 12 miles from its junction with the Columbia, and 110 miles from the sea. It is the head of navigation for deep-sea going vessels and the principal financial, commercial, and shipping point of the northwest territory of the United States. It owes its importance to its location relative to the fertile country which surrounds it and with which it is connected by water and by rail. The products of this country are brought to its port for shipment, and the supplies and exchange products are centered here for distribution. Its present prosperity is also largely due to the conservative far-reaching business acumen of its leading merchants and business men. During the past year the value of the exported wheat, flour, and other products, as given by the president of the chamber of commerce, amounted to $14,000,000. The jobbing trade of the city is estimated to be $138,127,000 for the same year.

Prior to June, 1891, the city now known as Portland consisted of three separate municipalities, Portland on the west side of the Willamette River, with East Portland and Albina on the east side. At [illegible] time, under authority from the legislature of the State of Oregon [illegible] a vote of the people to that effect, the three municipalities were [illegible]ited into one. The last census prior to the consolidation showed the [illegible]bitants in each to be, Portland 51,000, East Portland [illegible]a 5,169. It is claimed that the increase in population [illegible] will bring the total up to fully 75,000.

[illegible] healthy growth in all directions, especially so to the [illegible]on the east side of the river in what was Albina and [illegible] Being separated into two parts by the Willamette [illegible]on of communication across the river is one of great [illegible]ose whose business or occupation [illegible] that they

pass from one side to the other. The length of the river included between the extreme northern and southern boundary lines of the city is approximately 10½ miles. The width between the harbor lines recently recommended for adoption by the harbor line board, appointed by order of the Secretary of War, varies from 600 feet to 1,200 feet, and the depth in the channel from 9 to 95 feet. The discharge of the river at low water is about 15,000 cubic feet per second, while that for the extreme flood of February, 1890, was estimated from rough discharge observations to be about 400,000 cubic feet per second. This flood reached a height of 28 feet above low water. The mean velocity of the current was above 6 miles an hour.

Regular communication is had between the east and west portions of the city by means of three bridges and two ferries. These latter have submerged wire ropes along which trolleys are made to run, which have the boats fastened to them propelled by steam power. The ferries are located, one at Knight-Quimby street, the other at Stark street. Other ferry franchises exist but are not at present used.

The first bridge to be observed while coming up the river is the steel railroad bridge. This is located at the narrowest point on the river within the limits of the city and is 660 feet long between abutment piers. It consists of one draw span and one closed span. The draw is at the western end and has a length of 340 feet, giving a clear opening on either side of the pivot pier of 150 feet for the passage of vessels. Owing to the fact that the right of wharfage has not been extinguished in favor of navigation in the vicinity of this bridge, the west draw opening is of little practical use to boats in passing. There are large ships or ocean steamers lying almost constantly at the docks immediately above or below this end of the bridge. The closed span is 320 feet in length and at the east end. The lower chord is but 2½ feet above the extreme high water of February 18, 1890. The bridge has two roadways, one above the other. The lower is used exclusively for the passage of railway trains upon a single track, the upper for wheeled vehicles, street cars, and pedestrians. It is 18 feet wide, with footpaths outside, each having a width of 4 feet. The draw is maneuvered by steam power. The axis of the bridge is perpendicular, or nearly so, to the axis of the current.

The bridge was built in 1888 by the Multnomah Bridge Company under an act of the legislature of the State of Oregon. It is now owned or controlled by the Union Pacific Company. The upper roadway is leased for a term of years to the City and Suburban Street Railway Company. The tolls collected are regulated by the judge of the county court. No extra fare is collected from persons in street cars.

The Morrison street bridge is located about 4,600 feet above the steel bridge. It is 1,244 feet in length between abutment piers, divided into three spans 262 feet each on the east end, a draw 307 feet in length and a span of 151 feet at the west end. The openings on the two sides of the pivot pier measured along the axis of the bridge are 136 feet each, but in consequence of the location and the direction of this axis with reference to the direction of the current, the available space for the passage of vessels is reduced to 115 feet. This bridge is 20 feet wide in the clear with 6-foot sidewalks on each side. The roadway is occupied by a double-track street railway. The draw has been operated until lately by hand power. Recently an electric motor has been employed to turn the draw span. The street-car franchise of the bridge has been let for a term of years to the City and Suburban Street Railway Com-

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pany. The tolls collected are regulated by the county court. No extra fare is collected from persons in the street cars.

Under an act of the legislature of the State of Oregon, approved October 18, 1878, the Willamette Iron Bridge Company began the construction of this bridge in October, 1880. So manifest was it that the bridge would be an injury to navigation and to wharf property above its location, that great opposition was at once developed to its construction. The power of the Secretary of War was invoked to prohibit it. Investigations and adverse reports were made by officers of the Engineer Corps. The matter was taken into the courts, and on a hearing before the United States circuit court for the district of Oregon the work of construction was enjoined. In 1886 the arrangement of the piers and the width of draw opening were slightly changed and the work of construction proceeded with. The bridge was completed in the early part of 1887, and has proved to be an unreasonable obstruction to navigation and a detriment to the wharf property above its location.

Madison Street Bridge is located 1,300 feet above Morrison street. It was built in 1890 by the Columbia Street Bridge Company under authority of an act of the legislature of the State of Oregon approved February 25, 1889. It has a length of 1,654 feet between abutment piers. This is divided into seven spans of 191 feet each and a draw span of 317 feet. There is one closed span on the western end between the draw and the shore. The draw span gives an opening on each side of the pivot pier of 140 feet when measured along the axis of the bridge; but such is the direction of this axis with reference to the currents of the river that the clear space available for the passage of boats at ordinary stages of the water is limited to 120 feet. The bridge is 20 feet wide in the clear, with sidewalk on each side 6 feet wide. The draw is maneuvered by electric power with auxiliary hand-power attachments. It is, like the Morrison Street Bridge, an unreasonable obstruction to navigation, particularly as the draws have not a proper correlation with each other. During last winter it was sold to the city council of Portland and by this body turned over to the Portland bridge committee, and is now operated as a free bridge.

Neither of these bridges are constructed under act of Congress. The Madison street bridge, although built in 1890, was practically finished before the river and harbor act of September 19 of that year went into effect. Its plans and location, therefore, have not been approved by the Secretary of War.

The ferries mentioned and these bridges, together with small steamers plying up and down the river from one side to the other and stopping at almost every street, are the ordinary available means of communication between the two parts of the city. Although the ferries are primitive, inexpensive affairs in all their appointments and appliances for taking care of and transporting their patrons, and the bridges are far from being first class as a means for getting from one side of the river to the other, yet it does not appear that either of the ferries or bridges is taxed to anything like its full capacity. The volume of business and the general lines of traffic seem to concentrate toward the river between Madison Street Bridge on the south and the steel bridge on the north. There is great activity among agents and owners of real estate located on the peninsula lying between the Willamette and Columbia rivers. Special efforts are being made by these to induce persons to locate on their lands, which have been subdivided into lots and laid out with streets. On some of these are street

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railroads which cross existing bridges without extra charge to passengers. The traffic over these, although considerable and growing, is not by any means excessive.

Before the erection of the Morrison Street Bridge, which was the first to be thrown across the Willamette River in this vicinity, ocean-going vessels ascended above its site and received their cargoes. A system of wharves and docks was projected by the Oregon Railway and Navigation Company on their land, which lies 1 mile above this. They designed bridging the river at Ross Island, thus leaving all below free and unobstructed for the commerce of the port. This river is now susceptible of easy navigation by deep-sea vessels to this point, were it not obstructed by bridges; and it is capable of being made navigable at reasonable expense by vessels drawing from 14 to 16 feet of water at all stages for 10 miles farther up. This company, being cut off from their lands by an obstruction in the river, was obliged to make other arrangements for connecting with ocean transportation. They have crossed the river 2⅝ miles below, at the steel bridge, and, as a consequence, have practically diminished the space otherwise available for accommodating ocean traffic to this extent. There is in this distance about 28,000 feet along the harbor lines that could, at reasonable expense, be made available for shipping were it not for this one unfavorable condition. Deep-sea ships do occasionally go above the steel bridge when there is little or no current in the river. There is always extra risk and extra towage charges for taking ships above the upper bridges. Twenty-five dollars for each bridge each way is now charged by the Union Pacific Company for towing ships through the upper bridges, and when there is any considerable current in the Willamette the company will not assume any risks. Freight is taken through the city from the docks above Madison Street Bridge to be loaded into ships at docks below the steel bridge at an expense of from 35 to 40 cents per ton.

The city council has provided by ordinance that ships may not lie at anchor above Knight-Quimby street ferry. This is apparently with the view to keeping all that portion of the harbor as free as possible from obstructions that might interfere with the passage of vessels.

The harbor limits below the steel bridge are usually considered to extend to the head of Swan Island, or about 2 miles downstream. Should the commerce at any time in the future grow beyond what can be conveniently and economically accommodated within what is now considered the harbor limits, these can be extended indefinitely down the Willamette and around on the Columbia River side of the peninsula.

Within the present limits and below the steel bridge are located the principal docks at which nearly all the deep-sea transshipment takes place. The principal railroad termini are here, with all their warehouses, elevators, freight depots, switching tracks, and other facilities for handling the products and supplies of the country, and this location is apparently chosen with the direct object of having the great volume of the heavy business of the city below all bridges.

During the year 1891 there were one hundred and three sailing vessels loaded at Portland for foreign ports with wheat and flour, valued at over $7,000,000. Not to exceed ten of these were partially loaded above the steel bridge. In addition to this, flour and wheat to the value of nearly $4,000,000 were shipped from this port in ocean steamers. These figures are mentioned with the view to showing the interests involved in one direction only in any proposed curtailment of the harbor facilities.

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As a matter of interest bearing upon this subject the Board has investigated, to a limited extent, the practice with regard to bridging their harbors and the rivers which connect them with the sea, of the principal inland commercial cities of the world, reached by deep-sea vessels. Practically in every instance it was found that bridges are not permitted below the point where deep-sea ships go. In no instance has the Board been able to learn of any great seaport favorably considering the bridging by low bridges of its harbor or connections with the sea.

The following instances coming under this head are mentioned:

London, the metropolis of the world, is situated on the Thames River, 60 miles from the sea. In the stretch of river, nearly 7 miles long, comprising the shipping district, and with enormous interests of all kinds on both sides of the river, there is no bridge below the absolute head of deep-water navigation at the London Bridge. A new bridge is being built at the Tower of London, a quarter of a mile below the London Bridge. This, when completed, will have a clear opening of 200 feet for the passage of vessels, and is required to be kept open, except for a very short time during the day. All crossings in the 7 miles of city below the London Bridge are made by ferries and by tunnels under the river.

The great port of Liverpool, on the Mersey, has allowed no bridge to be built across the lower navigable portion of the river. Between Liverpool with a population of over 500,000 and Birkenhead, on the opposite side of the river with a population of 100,000, communication has until recently been kept up entirely by means of ferries or by a very circuitous railway journey.

Recently there has been constructed a tunnel under the Mersey for the accommodation of railroad and local traffic. This was built at a cost of nearly $4,000,000, whereas a bridge could have been constructed for a very small part of this sum.

The river Clyde, upon which is situated the great commercial city of Glasgow, with a population of over 500,000, has no bridge across it from its mouth for a distance of 21 miles, the entire portion used by shipping. The first bridge is a stone-arch bridge at the absolute head of navigation.

The river Tyne, upon which is situated Newcastle, has no low bridge until a point above the city is reached, a distance of fully 12 miles from the mouth. A high-level bridge crosses the Tyne below the city, but in consequence of its height is no obstruction to navigation.

The river Tees is crossed by no bridge below Newport and Middlesborough.

The river Dee is crossed by no bridge at or below Chester.

The city of Bristol, the third commercial city of England, has connection with the sea by the Severn and Avon rivers. Neither of these rivers is crossed by a bridge until a point above that to which ships can go is reached. Until recently, steam ferries across the Severn gave Bristol her only communication with the railways to the north.

To furnish better communication without obstructing navigation, there has recently been built a tunnel under the Severn. This tunnel, with its inclines for railroad traffic, is over 4 miles long.

At Belfast, the chief manufacturing and commercial city of Ireland, the bridges across the river Lagan are confined to the upper part of the city. None are permitted in the portion of the river in the vicinity of the docks, quays, and basins reached by deep-sea ships.

The same is true of the city of Dublin, situated on the river Liffey.

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Hamburg, the first commercial city of the continent of Europe, is situated upon the Elbe, about 93 miles from its mouth. Upwards of 5,000 deep-sea vessels enter and depart from this city annually. The city proper lies on one side of the Elbe, and on the other side are the two cities of Altona and Ottensen, the three presenting to the river a continuous frontage of over 4 miles. Throughout this entire distance there is no bridge to obstruct or incommode navigation. All crossing is by means of ferries.

The great commercial city of Rotterdam has guarded its navigation interests to an extent that there is no bridge across the river Maas from about the middle of the city to its mouth, a distance of 21 miles.

The river Scheldt, from its mouth to Antwerp, a distance of 60 miles, is not crossed by a bridge at the city or below it.

The great city of Amsterdam on the river Y has never permitted its navigation interests to be interfered with by the erection of bridges across the river.

The river Adour up to the city of Bayonne is uncrossed by any bridge.

The river Seine is not crossed by a bridge at Havre or for 40 miles up the river.

Bordeaux, on the Garonne, is one of the chief commercial cities of France. It is about 60 miles from the sea. In this whole distance no bridge crosses the river or estuary. In the upper portion of the city is a stone-arch bridge forming a complete bar to ocean ships. No bridge is permitted below this, all railroad and other crossings being above.

Calcutta, the capital of India and commercial capital of the continent of Asia, is situated on the Hugli River about 80 miles from the sea. It is reached by the largest ocean ships. The commerce of this great city is not permitted to be interfered with to the slightest extent by bridges.

No bridges cross the St. Lawrence below the point at Montreal reached by deep-sea vessels. Bridges are not permitted to interfere with the harbor or commerce of Montreal, which is nearly 1,000 miles from the sea.

In our own country no bridge except the high bridge passing entirely above the shipping has been permitted or would be for a moment considered across the waters of New York Harbor. Not even a pier for a bridge is allowed outside the established harbor lines.

There is no bridge over the Delaware at or below Philadelphia.

There is no bridge across the Mississippi below New Orleans, 107 miles from the mouth of the river. A recent proposition to bridge the river below New Orleans has called forth a storm of indignant protests.

The Long Bridge across the Potomac at Washington has been considered a great detriment to the commerce of Georgetown, and strenuous objections have always been made to another drawbridge above it.

In some of our lake cities there are bridges over the small rivers flowing through them, and much of the shipping is done at docks above these bridges. This is particularly the case at Chicago. During the early development of the commerce of this city the lake vessels were by force of circumstances compelled to do their business along the Chicago River. The lake front was not at that time available for dockage. The city rapidly enveloped the river, extending its streets in all directions across it and establishing communication by means of tunnels and bridges.

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The situation has now become so grave in respect to the two conflicting interests that shipping is being gradually withdrawn from the river and provided with facilities in other locations at the lower end of Lake Michigan; and it is seriously contemplated to close the river entirely by making all bridges permanent without draws or arching the river over its entire length.

When the question of the erection of the Morrison Street Bridge was before the public in 1880, and from that on to 1886, some very strong remonstrances were made against its construction. The facts and reasoning then brought forth are equally applicable at this time in the consideration of the bridges which it is now proposed to erect. In his remonstrance against the erection of the Morrison Street Bridge Mr. Henry Villard, then president of the Oregon Railway and Navigation Company, says—

That such location, it will be observed, is about the center of the city front, and at such a point as to necessarily create a most serious obstruction to the shipping of the city on at least one-half of its river front.

* * * * * * *

That the construction of a bridge at the point designated would seriously interfere with the navigation of said river, and the commercial interests of the city of Portland, the State of Oregon, and the commerce of the Pacific Ocean centering there as well. During the past two years shipping facilities, in the way of wharves, warehouses, roadways, etc., have been erected along the Portland city front south of Morrison street (the site of the proposed bridge), and a very large proportion of the commerce of said river, and of the city of Portland, is now transferred to that portion of said river lying south of Morrison street, and all of which will be seriously and permanently affected by the construction of any bridge at Morrison street; no matter how carefully provided with draws, such proposed bridge will, in the judgment of this company and of those interested in the navigation of said river and the commerce of said port, prove to be at all seasons of the year a serious obstruction to its navigation, affecting materially and adversely its shipping, both above and below the proposed bridge.

And at times of high water this obstruction will be so serious as to prevent the passage of seagoing vessels, at least without great danger. The current of the river at and above the site of the proposed bridge in times of high water is unusually swift; this, together with the want of room to enable vessels to swing before entering the draw, would constitute a bridge at that point as little else than an impossible barrier to navigation above it by ocean vessels.

In rendering their opinions upon the different points that were passed upon in the injunction proceedings brought to restrain the construction of the Morrison Street Bridge, the judges of the United States circuit court for the district of Oregon made use of the following language:

A bridge of a certain character at a certain place may be of great benefit and convenience to a few people or some petty local trade or business, but a serious inconvenience or injury to many people and a valuable and extensive commerce.

The commerce of Oregon, both domestic and foreign, is largely dependent upon the free navigation of the Willamette River. Steamboats ply upon it most of the year for 100 miles or more south of Portland. At Portland the tide ebbs and flows, and from there to its mouth, a distance of 12 miles, it is navigated by sea and inland vessels, foreign and domestic, sail and steam, that go thence up and down the great Columbia, out upon the Pacific Ocean, and to all the principal ports of the world. It is the harbor of Portland, the emporium and financial center of the Northwest, where the valuable products of the country are gathered from far and near and stored for market and exportation, and the imports from the sister States and foreign countries are received and distributed throughout the interior.

* * * * * * *

Upon the evidence and in the very nature of things there can be no doubt that this bridge, where and as it is being constructed, is a serious obstruction to the navigation of the river.

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Indeed, the further investigation of this matter makes it appear very probable to my mind that no bridge, unless it be a suspension one, can be constructed over the

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river at this point without being a serious obstruction to its navigability and impairing its usefulness as a common highway for the citizens of the United States.

The Willamette River in front of Portland is not only a navigable stream with a ship channel; it is also a seaport, as I have before said, of "the emporium and financial center of the Northwest," and to all appearance is destined to be second to no city in importance on the Pacific Coast, save one.

Every bushel of grain grown for export over this vast region, and particularly in the great Willamette Valley, feels the cost of storage and dockage at this port, and anything which limits or restricts the capacity or convenience of its harbor works a direct injury to the great body of the producers throughout the country.

Therefore it is that the convenience of the comparatively small population immediately east of Portland, or even in Portland, is not alone to be considered in this matter.

The river is the navigable water of the people of the United States, and the harbor is for the free use of all the people whose exports and imports freight the vessels that frequent it from all parts of the world.

At this point, on the west bank of the river, the ox teams of the Willamette Valley first met the seagoing vessel, and the traffic between them was the beginning of Oregon's commerce. Out of this commerce grew the town of Portland. But destroy, or materially restrict, or impede the free use of this harbor, or the approaches to it, and so far you destroy the town and injure the commerce of the country.

* * * * * * *

Located as it is, right in the midst of the harbor, where vessels are required to move constantly from place to place, without a passage, except at the single point of this draw, the bridge will be a serious obstruction to navigation in the harbor, even if the draw was sufficient for the passage of vessels up and down the stream.

The act of Congress does not limit the free navigation of the river to a particular part or channel, but it declares the whole river a free and common highway to the full extent of its capability of navigation.

A bridge may not be a material obstruction to the navigation of a river if erected at a point where vessels simply pass up and down a channel on their way to and from a port, but in the case of a harbor like this, the location, surroundings, and the circumstances must be considered, and they may require that no part of it be obstructed or closed to navigation. In this view of the matter I think that any bridge in this harbor would necessarily be such an obstruction to its navigation as to require the consent of Congress to justify it.

This place is a commercial center, the second port of importance on the Pacific coast, mainly because ocean vessels of a large size can come to its docks.

Therefore it is a serious question whether the people of Portland or the State of Oregon can afford to allow a bridge to be built in the midst of this harbor, at a point where ships must congregate, and thereby create such an obstruction therein as may, and probably will, turn the commerce of the city in other channels.

This harbor is not large, and when the shipping here is much increased, as it doubtless will be with the growth of the country and the place, there will be no room to spare for it.

* * * * * * *

All these things are to be considered in determining whether it is good policy, even if Congress could be brought to consent to it, to bisect this harbor with a bridge that would render it unnavigable along its line, except at a particular point.

The experience of the last ten years will fully justify the conclusions arrived at by these eminent jurists.

Before entering upon a recital of its proceedings in connection with the subject it has been convened to investigate, the Board has considered it necessary to a clearer understanding of its conclusions to set forth the foregoing facts and circumstances, as they seem to have an important bearing upon the question whether or not plans for any bridge over the Willamette River within the limits of the city of Portland should be approved by the Secretary of War.

For some years prior to the consolidation of the three cities—Portland, East Portland, and Albina—into one corporation the question of free bridges across the Willamette for the accommodation of certain classes of these communities received considerable attention and figured more or less in local politics. Through the efforts of some who are particularly interested in the matter an act was passed by the legislature of the State of Oregon authorizing the creation of a bridge committee

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and defining its powers and duties. This committee by the act is authorized to purchase or lease, either by agreement or by condemnation, existing bridges and to erect new ones; also to sell its bonds to the extent of $500,000, which amount, together with interest and expenses necessary to the maintenance and operation of said bridges, becomes an obligation on the part of the city of Portland. Under authority of this act this committee purchased the Madison Street Bridge at a cost of $142,500, and this is now a "free bridge." The committee now bring forward plans for two bridges which they desire the Secretary of War to approve, which approval it is required both by the State law under which they are acting and the United States law must be obtained before it can proceed with the construction of either of the bridges.

One of these proposed bridges is located in the heart of the city at Burnside street, about midway between the steel bridge and Morrison Street Bridge, the other 3,000 feet below the steel bridge, crossing from Knight street on the east side to Quimby street on the west side.

In this case, as in all others where different interests are involved, there is a conflict of opinion. The Board took steps to ascertain, as far as possible, what were the wishes of the people in regard to these bridges, especially the large thinking class of the community who are supposed by their actions and their influence to control and direct matters of public importance. Communications setting forth the object for which the Board was convened, and giving an opportunity for expression of opinion before it, were addressed to the president of the chamber of commerce; the president of the port of Portland commission, an organization created by State authority for the purpose of improving harbor facilities and the navigation of the Willamette and Columbia rivers to the sea; to the president of Columbia River Steamboat Association; to railway managers and various steamboat owners, captains, and pilots. Copies of the communications alluded to in this report, together with stenographer's report of public meeting, petitions, and other papers are herewith attached as appendices.*

The chamber of commerce of Portland, Oregon, is a corporation formed "to advance the commercial, mercantile, manufacturing, and industrial interests of the city of Portland and the State of Oregon generally * * * and to consider all subjects of internal improvements that may be for the welfare of the community and the State at large." It has a membership of 570, the board of directors consisting of as many as there are members.

The communication was considered at its regular meeting held May 10, at which there were present 32 members, as shown by the votes. It was then decided that the subject of the communication was not a matter of which the chamber could take official notice, and notification to this effect was received from its president. This reply and the fact that there were not more members present to consider a subject of so great importance to the commerce of the city was a matter of great surprise and regret to the Board.

A reply to the letter addressed to the president of the port of Portland commission was received, inclosing preamble and resolutions adopted by the Board of commissioners at its regular meeting held May 12, 1892, the purport of which is that additional bridges would be prejudicial to the commercial interests of the city.

Replies were received from some others which will be found appended.

In order to give opportunity for a more extended hearing the Board

*Not reprinted; printed in Senate Ex. Doc. No. 118, Fifty-second Congress, first session.

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after due public notice held a public meeting May 17, in the rooms of the chamber of commerce in the city of Portland. A letter was addressed to the chairman of the bridge committee notifying him of this meeting and requesting that he and other members of the committee be present. The meeting was liberally attended and a number of individuals favored the Board with their views. The remarks of the principal speakers will be found appended. A number of petitions were presented which relate to particular locations and which seem to have been originally addressed to the bridge committee but have been withdrawn from the files of that office and presented to the Board.

If these petitions and the remarks made at the public meeting indicate anything to the Board, it is that there is a very strong opposition to the location of a bridge at Burnside (B) street, and many people at Albina are very desirous of having a bridge for their accommodation at Knight-Quimby streets. The chairman of the bridge committee was not present at this public meeting, and no one seemed to be there who favored the Burnside street location. The pilots and steamboat men remonstrate against the building of this bridge. A communication was received, signed by a large number of the men who own or control the wharf property and docks along the water front, who are engaged in the shipping and commerce of the port, and who furnish largely the money by which the business of the community is carried on, setting forth clearly their reasons why additional bridges should not be constructed, and objecting especially to the proposed bridge at Knight-Quimby streets. In view of the interests represented by the signers of this communication, and the large aggregate of the value of the property upon which they pay taxes, it is entitled to great consideration.

The interests of the Union Pacific Company were represented at this meeting in the absence of the manager, Mr. McNeill, by Mr. Cotton, the attorney for the company. The argument of Mr. Cotton was to the effect that the competition between Portland and ports on Puget Sound as shipping points for the products of the country and distribution of supplies was now very close, and that anything which increased the expenses of shipment from the city of Portland militated against her commercial prosperity. The construction of either of the proposed bridges, especially the one at Knight-Quimby streets, would necessarily increase the towage charges and the risks to be provided for in passing the bridges, which would tend to her disadvantage in this close competition. On the contrary, everything possible should be done to diminish port and towage expenses and favorably influence men who are disposed to send ships to this port.

The remarks of Capt. Bolles, who has for a number of years been navigating ocean steamers between San Francisco and Portland, are very much to the point and throw light upon the difficulties experienced at bridges when such vessels are obliged to pass them. Capts. Patterson and Smith are also pilots of long experience in this port and know whereof they speak in relating their difficulties at the present bridges and objections to additional ones. These gentlemen emphasize the fact that to handle large ships in this port when there is any considerable current in the Willamette River is a difficult and dangerous task if these have to be taken past either of the existing bridges. The risk is great and will not be taken without proportional increase in the cost of transporting the ship's cargo.

All those who expressed themselves at this meeting as in favor of the location of a bridge at Knight-Quimby streets, or, as it is generally

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termed, the "Albina bridge," were considering the facilities for communication between the two portions of the city, and argued that the increased advantage to be gained by those living in that vicinity were of more importance than the inconvenience resulting to navigation and commerce. The necessity for the bridge was not clearly demonstrated to the mind of the Board by the arguments of these gentlemen; nor was it by any means made clear that its construction at that point would not be an obstruction to navigation and a serious detriment to the commerce of the port.

It was asserted that from 15,000 to 20,000 people would be benefited by the construction of this Albina bridge, which assertion, however, the Board does not think is correct as applicable to the present time. It is possible that the population of this portion of the city may in some years hence amount to something like these figures, but it certainly does not at present. It is evident that the building of this bridge would immediately increase the present price of real estate in this direction and greatly benefit those who have this for sale. It would also eventually force the deep-sea shipping below its point of location, which might inure to the benefit of water-front owners in that direction. It is not believed that these are sufficient reasons to justify the deterioration in the value of the property along the water front which is now used for shipping purposes that would surely take place were this bridge built, nor is it shown that the necessity for benefiting 20,000 people that might wish to use this bridge is sufficiently great to justify the inconvenience and danger that it would be to shipping and river commerce, or the increase in the cost of placing in the markets the products of the whole country tributary to Portland.

It is clear to the Board that this bridge is not a necessity at this time, and that the demands for increased transportation facilities across the river are not such as to warrant interference with the river commerce to such an extent as to necessitate a readjustment of the present shipping arrangements or seriously jeopardize the prosperity of the port.

At this point in the investigations of the Board it appears that there is very great opposition to the location of a bridge at Burnside street, and nothing has developed in favor of that position further than the mere request of the bridge committee that the Secretary of War approve the plans submitted by it. In view of the very respectable opposition to the construction of a bridge at this point, and in fact at any point on the river, that manifestly exists among the citizens, it was thought necessary to inform the bridge committee of this fact and request information from it as to the necessity for the bridges that they propose to construct. The organic law under which the committee acts provides for raising funds only to the extent of $500,000 to be expended by it. Having expended probably $150,000 in the purchase of "Madison Street Bridge," and in defraying other necessary expenses, it occurred to the Board that what remained of this sum would not be sufficient to construct two bridges of the dimensions and character that should be built here, in case objections could be so far overcome that any plans could be approved by the Secretary of War. In that case which was to have the preference as the plans of a bridge whose construction is indefinitely in the future evidently need not be approved at the present time. And also the bridge committee having authority to buy, lease, or condemn existing bridges, why not make arrangements for giving the public the free use of these, since there exists such strong and reasonable opposition to additional obstructions being placed in the harbor at this time?

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A communication covering these points was addressed to the chairman of the bridge committee, which committee after due consideration made answer by transmitting to the Board a series of papers, consisting of original petitions that had been made to it favoring the two locations selected; a report of the committee's engineer on an examination made by him of the Morrison Street Bridge; two resolutions, one setting forth reasons why a bridge should be erected at Knight-Quimby streets, the other giving reasons for the erection of one at Burnside street; and a letter which reveals the fact that the bridge committee has not yet agreed upon the kind of bridges that it intends to erect, but desires that this matter be left to its discretion to be determined hereafter.

The Board has given careful consideration to these papers, and is forced to acknowledge that they do not give the clear, definite, and reliable information upon these points that seems to be necessary in the case.

In one of these papers drawn up in the interests of the Albina bridge assertions such as the following are made: "Fully one-third of the residents of the city of Portland live near to, below, and north of said bridge site." "Over one-half of the laboring class live tributary to said proposed Knight-Quimby street bridge site." "A large majority of the manufacturing industries of the city are located near to and below said proposed sites." "One-fourth of all the taxes to be paid for construction and maintenance of the proposed system of free bridges will be so paid by residents and manufacturing industries immediately to be benefited by the said proposed Knight-Quimby street bridge." "This bridge would be but a small obstruction to navigation."

To all of these statements the exception can be taken that they are not accurate, and it can be easily demonstrated that they are not warranted by the actual facts in the case.

Further on in the same paper the assertion is made that "this committee have received proposals from a reliable company offering to build a steel bridge five blocks below the present Morrison Street Bridge for $75,000." This as it stands does not convey a correct idea of the facts. A company did offer to build a bridge as stated which would cost more than twice the amount named, and would sell it to the bridge committee for $75,000, provided the company could reserve certain rights and franchise over the bridge which it was supposed would more than compensate it for the difference.

It is also stated:

> As to the railroad bridge, this committee have made proposals to the owners and parties in control thereof with a view of leasing the upper roadway, but so far have been unable to get any definite and reasonable proposition.

In connection with this assertion the Board will quote from a letter received from the general manager of the Union Pacific system, Pacific division:

> In addition to what has been written by us, and stated before your committee, protesting against the erection of further bridges, I would like to-day to refer to the fact that there are two existing bridges which are not free, both of which are suitably located with reference to traffic between the east and west banks of the river, and one of which belongs to this company, and to say that I am not aware that any real business proposition has been made to anyone in authority looking to the opening of these bridges to the public. I understand that propositions have been made, but they have been rather informal, and I might, perhaps, say that the opinion has been expressed that these propositions have been much below what the owners consider their property is worth; in short, more nearly based on what these properties would be worth after competing bridges have been erected. It would seem to me, therefore, that before permission be given to seriously injure the harbor by the erec-

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tion of further bridges that it should be positively known that every reasonable effort had been made to secure the same results by means of existing bridges. Finally, as the owners of a vast amount of property on the river front, and as the operators of a large number of boats, I do most vigorously protest against the building of further bridges, believing that the damage and injury that will result to the harbor and commerce, by reason of such bridges, will far more than offset any possible advantages therefrom.

Also, it is stated—

Propositions were made to the owners of the Morrison Street Bridge to buy the same, and they answer saying they would not sell same and all rights connected therewith for less than $200,000.

In this connection reference is invited to a communication from the president of the City and Suburban Railway Company, found in the appendix, in which the following statements are made:

I should suppose that I am in position to know what propositions have been made or proposed looking to the free use of either of the bridges north of Madison street, yet no such proposal has, to my knowledge, been made or suggested by the bridge committee. A proposition was made by the owners to sell the Morrison Street Bridge to the committee at a price equal to the cost of the same, being $200,000. This proposition was pending for some length of time, during which numerous communications and several editorials appeared in the press of this city, strongly advising against the purchase, and the proposition was rejected by the committee in no very considerate terms.

It would appear that the owners of the Morrison Street Bridge have made a proposition to sell to the bridge committee which was not satisfactory. It does not appear that the committee has made a counter proposition of any kind looking to the free use of this bridge by the public.

It is further stated in this paper "that nine out of every ten of the voters and taxpayers of this city desire this committee to construct the system of bridges contemplated." This is also a wild assertion which there are no facts to substantiate.

In another of these papers advocating exclusively the construction of a bridge at Burnside street, it is stated—

It is well known to you that the cities of Albina, East Portland, and Portland recently consolidated. One of the chief considerations leading to consolidation was the provision for free bridges, which, upon being submitted to the vote of the people, was agreed upon at the rate of about 3 to 1.

The Board is not aware that the question of "free bridges" across the Willamette River has ever been specially submitted to a vote of the people, as is plainly implied by the above language. Before the consolidation of the three cities could take effect it was provided in the act of the legislature authorizing this that the question of consolidation should be submitted to a vote of the people. The vote on consolidation was about as stated. The free bridges were provided for by act of the legislature while the cities were yet separate.

In this paper it is also stated—

We have found it impossible to procure these present existing bridges under our powers for the purposes required.

The needs of a free bridge to the inhabitants of both sides of our river at Burnside street have become an absolute necessity, and the acquirement of the Morrison Street Bridge or the railroad steel bridge, after every reasonable effort and full examination, is impracticable and has become impossible.

In our judgment we have sufficient funds to construct the bridges located by us.

In the face of the large volume of what seems to be reliable evidence to the contrary, the Board cannot accept these mere assertions as the conclusive information that is desired.

With regard to the amount of funds at the disposal of the bridge com-

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mittee with which to construct the proposed bridges it appears that this will not exceed, say, $350,000. Should it at any time be made to appear that the interests to be subserved by the erection of one or both of these bridges are of so great importance as to warrant the sacrifice which must necessarily be made by the shipping and navigation interests, then there are other interests which would require that these be wide, commodious structures, substantially built, supplied with all modern machinery for rapid maneuvering of the draw spans, and first class in every respect. The plans of a bridge that is not of such a character should not be approved by the Secretary of War. If it is needed badly enough to justify a sacrifice of the river commerce, it certainly should warrant the expenditure necessary to make a substantial structure.

The steel bridge rests upon a pivot pier for the draw, built originally in 35 feet of water, one other pier 60 feet, and the abutment piers. The west abutment pier was originally in about 10 feet of water at the low stage. The river floods have scoured out the bottom at the bridge site to such an extent as to endanger to a greater or less extent the pivot and west abutment piers. Since the flood of 1890 large quantities of rock have been thrown in around the foundations of these.

This bridge, which is not of a too substantial character, stands upon the books of the Union Pacific Company as costing $376,000. This, it is presumed, includes the cost of the approaches to the upper roadway. At the east end this is reached by one span 150 feet in length, and at the west end by two spans 150 feet each and one 125 feet.

The plans submitted for the bridge at Burnside street call for a pivot pier to be constructed in 65 feet of water at the low stage, nearly twice the depth in which the pivot pier of the steel bridge was originally constructed; two draw piers, one in 42 feet, the other in 62 feet of water, with an abutment pier at the west end in 20 feet of water, and one at the east end in 7 feet. The approach to this bridge on the east side is 650 feet long, and on the west side 200 feet. Those submitted for the Knight-Quimby Street Bridge call for a pivot pier in 25 feet and five other piers located in depths averaging 22 feet. The approach to this bridge on the east side is 240 feet long and on the west side 290 feet.

The Board can not agree with the bridge committee in its assertion that it has sufficient funds available to construct both of these bridges; and it would not feel warranted, were all other matters pertaining to them unobjectionable and satisfactory, in recommending that the Secretary of War approve the plans when there is a probability that the construction of the bridges might not be commenced, or that they might stand in the harbor, doing no service, in an uncompleted state for an indefinite time.

Since the public meeting held by the Board a petition has been received addressed to the Secretary of War in this interest, to which is attached a large number of signatures. This petition is forwarded herewith. The reasons given by the petitioners seem to be the same as already noted in the papers received from the bridge committee. The questions involved are those which largely affect the rights and property of others in Portland and outside of Portland who are not represented by petition. They can not therefore be decided by numbers unless it can be ascertained in some way what are the rights and property interests and wishes of all those concerned in the matter of the petition.

To illustrate the worthlessness of this petition as a source of information from which to ascertain the wishes of the people in this matter,

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the Board will observe that while there is claimed to be over 9,000 signatures to it, at the election held in Portland June 6 there were between 11,000 and 12,000 persons voting in the whole of Portland; and at the precincts in Albina and North Portland whose voters could under any admissible hypothesis be considered as tributary to a bridge constructed at Knight-Quimby streets, there were not to exceed 2,000 men voting. This was an important State election, at which it must be assumed that nearly all who were entitled to do so cast their votes.

With regard to the plans themselves, the Board will say that did they apply to the ordinary case of bridging a navigable stream with no modifying surroundings, where only ordinary river traffic was concerned, it could find little in them that would be objectionable, either as regards location, the direction of their axes with reference to direction of currents, position of draw openings, location of piers, or capacity or height above flood level. But this is not the case. Their construction will seriously affect to its disadvantage the prosperity of Portland as a seaport city and the value of the products received here from the interior for shipment for foreign ports.

If it should be concluded that the necessities of the traffic over the river between the steel bridge and the Morrison Street Bridge are such as to warrant the further incumbrance of this portion of the city's harbor with a bridge, the Board is of opinion that the Burnside street location is less objectionable than any other that could be chosen within these limits, but it does not think that the facts show that this time has yet arrived.

Fears have been expressed lest the construction of a bridge in this locality would result in an increase in the height of flood waters of the river, with results to the detriment of the adjacent property; and statements have been made upon apparent good authority that the Willamette high water of 1861 exceeded that of 1890, and that if such a flood as the former were again to occur, with the present condition of affairs in the harbor, the results would be disastrous in the extreme. This view seems to be based entirely upon the recollection of old settlers who resided at different points along the river at the time of the 1861 flood.

To establish this point definitely the Board has made investigations at different points in the river from Oregon City down, where well-authenticated high-water marks of both floods were found and the difference of level taken. In all cases the flood of 1890 was the highest. At Oregon City, about a mile above the falls, this difference was 2.8 feet; below the falls, abreast of the city, 1.8 feet. At Milwaukee 3.1 feet, and at Portland, Stark street gauge, from well-authenticated records, 3.5 feet. This would seem to establish beyond a doubt that more water came down the river in 1890 than in 1861, and that the increase in the height at Portland can not all be attributed to the wharves and bridge piers which obstruct the flow of water through that city and which did not exist at the early date.

This investigation also revealed the fact that at the site of the steel bridge, notwithstanding that the width of the waterway has been diminished 200 feet and the section obstructed by the bridge piers, there is now 5,000 square feet more area available for high-water flow than there was before the bridge was constructed. The bottom has scoured out to an average depth of about 17 feet below where it was originally.

Whilst it must be admitted that the placing of bridge piers in the river along the city front would have an undoubted tendency to increase flood height, the Board does not believe that this alone is of sufficient

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importance to stand as a bar to the construction of a bridge at Burnside street were there no other objections to urge against it.

The investigations that the Board has made upon this subject have led to the following conclusions, viz:

That the bridges which have already been erected over the Willamette River within the limits of the city of Portland are acknowledged obstructions to navigation upon that river and have been a material detriment to the value of wharf and dock property located above the steel bridge and to the freight and passenger traffic of the river; that the erection of an additional bridge above said steel bridge would further diminish the availability of this dock property for its legitimate commercial purpose, endanger property upon the river in times of high water, curtail the usefulness of this portion of the city's harbor, and otherwise result in detriment to its commerce; that in view of these facts and the present means of communication between the two portions of the city lying upon the east and west sides of the river, which do not appear to be utilized to anything like their full capacity, and of the fact that the erection of the proposed bridge is not authorized by an act of Congress, which would seem to be desirable in a case so important as this, it is not advisable that the Secretary of War approve the plans presented for the proposed bridge at Burnside street; further, it concludes that the construction of any bridge over the Willamette River below the steel bridge, except it be of sufficient height to permit vessels with the tallest masts to pass freely under it at all ordinary stages of water, should not under any consideration be permitted, for the reason that it would diminish the already limited harbor area available for deep-sea shipping, would produce loss to the owners of waterfront property above its point of location for which they could not be recompensed, would increase shipping charges upon the products of the country, and would result in a general injury to the harbor and to the commercial prosperity of the port that could not be compensated for by any convenience that might result to the traffic across the river. The Board has to recommend that the plans submitted for the proposed bridge to be erected at Knight-Quimby streets be not approved by the Secretary of War.

Respectfully submitted.

THOS. H. HANDBURY,
Major, Corps of Engineers.
THOMAS W. SYMONS,
Captain, Corps of Engineers.
HARRY TAYLOR,
1st Lieut., Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

LIST OF PAPERS ACCOMPANYING REPORT OF BOARD OF ENGINEERS.*

Letter to president chamber of commerce.
Reply to same.
Letter to chairman port of Portland commission.
Reply to same.
Preamble and resolutions adopted by port of Portland commission May 12, 1892.

*Not reprinted; printed in Senate Ex. Doc. No. 118, Fifty-second Congress, First session.

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Letter to F. R. Strong, chairman Columbia River Steamboat Association.
Reply to same.
Letter to sundry steamboat owners.
Letter from general superintendent Union Pacific system May 4, 1892.
Letter from general superintendent Union Pacific system May 30, 1892.
Letter from James B. Montgomery.
Letter from Hon. H. W. Corbett.
Stenographic report of proceedings of public meeting held May 17, 1892, with petition to Portland bridge committee asking that a bridge be located at Pine street; also remonstrance of sundry individuals against erection of any bridge in the harbor of Portland.
Remonstrance from sundry captains and pilots.
Letter to chairman Portland bridge committee.
Letter from chairman and clerk Portland bridge committee, May 23, 1892.
Letter from chairman and clerk Portland bridge committee, May 23, 1892.
Resolutions of bridge committee favoring construction of bridge at Knight-Quimby streets.
Resolutions of bridge committee favoring construction of bridge at Burnside street.
Three petitions of sundry persons to bridge committee to locate bridge at Burnside street (marked A, B, C).
Report of bridge committee's engineer on examination of Morrison Street Bridge, marked D.
Two petitions of sundry persons to bridge committee for bridge at Albina.
Letter from president City and Suburban Railway Company.
Petition of sundry citizens requesting approval of plans for proposed bridge at Burnside street.
Petition of sundry persons addressed to Secretary of War requesting approval of plans for proposed bridge at Knight-Quimby streets.

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APPENDIX Z Z.

OCCUPANCY OF AND INJURY TO PUBLIC WORKS BY CORPORATIONS AND INDIVIDUALS.

[Reported under section 2, river and harbor act of 1884, and section 4, river and harbor act of 1886.]

1. Report of Capt. Thomas L. Casey, Corps of Engineers.
2. Report of Col. William P. Craighill, Corps of Engineers.
3. Report of Maj. Charles E. L. B. Davis, Corps of Engineers.
4. Report of Maj. William Ludlow, Corps of Engineers.
5. Report of Col. O. M. Poe, Corps of Engineers.
6. Report of Capt. Dan C. Kingman, Corps of Engineers.

(1.) REPORT OF CAPTAIN THOS. L. CASEY, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
New York, August 23, 1892.

GENERAL: I have the honor to transmit herewith a report on "occupation or injury to piers," etc., to accompany my annual report for the fiscal year ending June 30, 1892.

Very respectfully, your obedient servant,

THOS. L. CASEY,
Captain, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

DIKES.

SOUTH RIVER, NEW JERSEY.

The Sayre and Fisher Company and William F. Fisher have occupied portions of dikes in the canal for several years. They have brickyards in the rear of the dikes; have filled in out to them, using the dikes as a bulkhead and landing for loading and unloading cargoes. No damage or injury has been done the dikes as yet. Sayre and Fisher applied for a permit to make this use of the dike in 1888, but owing to a dispute as to title to the land none was granted.

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CANARSIE BAY, NEW YORK.

In 1882 a permit was given one B. B. Remsen to construct a frame building on the end of the north dike, he agreeing to protect the dike from trespassing fishermen.

PASSAIC RIVER, NEW JERSEY.

The Jersey City, Newark and Western Railroad Company, through their contractors, Messrs. B. M. & J. F. Shanley, are working an injury to the dike in Newark Bay, in violation of section 9 of the river and harbor act of September 19, 1890, as mentioned in my annual report. They have made a solid fill along their grant of land under water from the United States dike marking the outer line of solid fill to the shore. This embankment, together with the dike, formed an inclosed basin of several acres. This basin must fill and empty through and over the dike and was rapidly undermining the structure. To protect it from destruction, dredged material from the Passaic River was employed to throw up an embankment inside the dike throughout its length. The inclosed water broke through, however, and the gap has recently been closed at additional expense. (See Annual Report Passaic River, page 873.)

The basin receives the drainage from a large area, several creeks in the salt meadow emptying into it. To maintain a draw along the dike will involve continual expense for care and labor. Any outlet made along the face must be badly located with respect to the important channels of the bay and certain to work injury to them.

The only proper location for tide gates or an open sluiceway is on the lower side through this railroad embankment, and should have been provided for in its construction.

(2.) REPORT OF COLONEL WM. P. CRAIGHILL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
BALTIMORE, MD., *July 5, 1892.*

GENERAL: In compliance with the requirements of General Orders 6 and 7, series of 1887, and 9 of 1888, from Headquarters, Corps of Engineers, I have the honor to report, concerning the rivers and harbors in my charge, that no additional information on the subject of those orders has been received by me since the last annual report with the following exceptions:

The honorable Secretary of War directed, in April, 1892, that report should be made to the United States district attorney of West Virginia (in compliance with section 11 of the act of September 19, 1890) of the injury done September 10, 1890, to Dam 5, Great Kanawha River, by certain coal boats which broke loose in the pool of No. 5 from the works of the Peel Splint Coal Company. This direction of the Secretary of War was at once carried out.

In reference to the tie-hoists at Point Pleasant, on the Great Kanawha River (Report of Chief of Engineers for 1891, page 3866), the indictment found in the United States court against the Kanawha and Michigan Railroad for filling up the river along the shore in operating these hoists is still pending. Mr. S. C. Burdett, assistant United

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States attorney, states that the case will probably come up for trial at the next term of the court.

No action has been taken by the court (except to bring the indictments found last year) against the coal operators on account of their coal tipple and breakwaters under the court's interpretation of section 7 of the act of September 19, 1890 (Report of Chief of Engineers for 1891, page 3867). As tipples and cribs are absolutely necessary in shipping coal and coke by river, these indictments unfortunately included all of the Great Kanawha operators who ship that way. In reference to these indictments, Mr. S. C. Burdett, assistant United States attorney, states that they

have not been pressed to trial, chiefly for the following reasons:

First. To await adjudication of preliminary motions in similar cases at other courts in the district.

Second. A number of cases have been held up, that application may be made by the owners to the Secretary of War for approval and authorization, under the provisions of section 7, of structures, some of which seem to be of public utility, but the continuance of which are technical violations of the law.

Several indictments were found previous to June 30, 1891, on complaints made by my direction against sawmill operators for throwing refuse in the river or placing it where it would be carried into the river in violation of section 6 of the act of September 19, 1890. In some or all of these cases small fines have been imposed, mainly on pleas of guilty. The court imposed small fines "because of the fact that the public generally was not familiar with the statute." The effect of this sixth section of the act has been excellent. The sawmills on the Great Kanawha and principal tributaries have stopped throwing edgings and sawdust in the river. Most of the large mills burn the refuse.

At the movable dams, particularly at No. 6, where so much trouble was experienced with sawmill refuse, no difficulty worthy of mention has been had from this during the year.

Relative to the Elk River, the following is the situation concerning the bridges, dams, and booms previously reported on.

No action has yet been taken on the indictments found last year against various parties owning small cribs, sheer booms, etc., in the Elk River, under the court's construction of section 7 of the act of September 19, 1890. Mr. S. C. Burdett, assistant United States attorney, states that the prosecution of these cases has been delayed for the same reasons that action against the owners of the coal tipples, etc., on the Great Kanawha has been postponed.

The United States district attorney, Mr. George C. Sturgiss, was furnished last winter with a list and description of the old milldams, the names of the owners, and a list of witnesses. Mr. Sturgiss stated in May that proceedings would be instituted against the owners of two of the worst of the dams, as trial cases, at the next term of the court. The court is now in session at Parkersburg, and it may be the proposed action has already been brought.

In regard to the Elk Island Boom at Sutton, the district attorney was notified last April of the complaints made about it by the lumber and sawmill men operating below Sutton. So far as known, no action has yet been instituted by the United States against the boom company. The boom is still seriously complained of by the lumber and sawmill men in the lower part of the valley—principally by sawmill operators at Charleston—on account of the enforced detention of their logs there. The litigation referred to last year between the Elk Island

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Boom Company and the Elk Boom Company of Charleston is still unsettled, though no further action has been taken in it during the year.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Colonel, Corps of Engineers, U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(3.) REPORT OF MAJOR CHAS. E. L. B. DAVIS, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., August 12, 1892.

GENERAL: In accordance with General Orders No. 6, Headquarters, Corps of Engineers, Washington, June 1, 1887, and General Orders No. 9 from the same headquarters, dated June 26, 1888, I have the honor to submit the following report upon the occupancy of and injury to public works by corporations and individuals:

OCCUPANCY OF THE POTOMAC FLATS BELONGING TO THE IMPROVEMENT OF THE POTOMAC RIVER, AT WASHINGTON, DISTRICT OF COLUMBIA.

Certain parties have been in the habit of using a portion of the land filled in by the Government near the foot of Seventeenth street NW., for the purpose of carrying on a traffic in building sand. The sand is brought in scows through the sewer canal across the flats and piled up on the land above described and thence removed by carts to various points of delivery in the city. The names of the parties so offending are: Henry Lyles, Henry S. McGlue, Louis M. Goodrick, Valentine Ruebsam, and John B. Lord, all residents of Washington. In addition, the last-named person, John B. Lord, builds barges, scows, etc., on the banks of the small tidal reservoir on the flats, hauling his materials for building the same through the large and small tidal reservoirs and their connecting channels.

As all this is in direct violation of section 9 of the river and harbor act of September 19, 1890, a report in accordance with section 11 of the same act, giving the information to the United States district attorney, was made July 18, 1892.

Very respectfully, your obedient servant,

CHAS. E. L. B. DAVIS,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(4.) REPORT OF MAJOR WILLIAM LUDLOW, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 1, 1892.

GENERAL: In conformity with the requirements of General Orders No. 9, of June 26, 1888, I beg to report the following cases of injury to harbor works:

August 10, 1891, the steamer *Petoskey* entered the harbor of Frank-

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fort, where the Government dredge was at work, and, passing the dredge, notified the engineer that if he were not out of the steamer's way when it returned he would be run into. Accordingly, on passing out the *Petoskey* struck the dump scow lying alongside the dredge, although there was ample room to pass, inflicting damages to the amount of $150. The facts in the case were notified to the United States district attorney.

May 5, 1892, the Government dredge *Saginaw*, while at work in the Muskegon entrance, was struck a glancing blow by the steamer *City of Racine*, breaking two spuds and disabling the dredge for four days. The damage, including loss of time, amounted to $290; but full inquiry showed that the steamer had made endeavor to avoid collision, and the damage was rather due to faulty handling than to carelessness or willfulness, for which reason the district attorney was not notified.

In addition to these particular cases, there are the frequent cases of injury from the throwing of fire into the works from excessive speed in the narrow fairways, which interferes at times seriously with the Government work, and always has a destructive action on the piers and revetments due to wave action and suction.

There are also the numerous cases of injury due to tying up to the piers and revetments, the lines being made fast to the legs of the elevated walk to the light-houses, and even the deck of the pier has been cut open to put a line on the cross-tie.

To meet these abuses in the absence of any local authority or control a draft of regulations was submitted, under date of February 22, 1892, pursuant to instructions of February 2 from the Chief of Engineers.

A copy of these regulations is herewith.*

Very respectfully, your obedient servant,

WILLIAM LUDLOW,
Major, Corps of Engineers,
Bvt. Lieut. Colonel, U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

(5.) REPORT OF COL. O. M. POE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 20, 1892.

GENERAL: In accordance with section 4 of the river and harbor act of August 5, 1886, and General Orders No. 9, Headquarters, Corps of Engineers, June 26, 1888, I have the honor to report the following cases where "piers, breakwaters, etc.," under my charge "have been used, occupied, or injured by a corporation or individual" during the fiscal year ending June 30, 1892.

OCCUPANCY OF PUBLIC LANDS, ETC., BELONGING TO THE RESERVATION OF ST. MARYS FALLS CANAL, MICHIGAN.

During the fiscal year ending June 30, 1892, the reservation has been occupied as reported in my last annual report, printed on page 3868 et. seq. of the Annual Report of the Chief of Engineers for 1891. No new cases of occupancy have occurred.

* Not printed.

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LANDS OCCUPIED BY UNITED STATES LIGHT-HOUSE ESTABLISHMENT.

Same as reported last year, see page 3871 of the Annual Report of the Chief of Engineers for 1891. No new cases of occupancy have occurred.

INJURIES TO PIERS, ETC., OF ST. MARYS FALLS CANAL, MICHIGAN.

On August 21, 1891, the steamer *A. D. Thomson*, bound down, ran into and crushed the southeast pier below the lock. Actual cost of repair, $41.44.

On June 30, 1892, the steamer *Pueblo*, bound up, ran into the northeast pier just below the lock, slightly damaging the pier and tearing off some of the sheet-piling. Estimated cost of repair, $33.64.

INJURIES TO PIERS, ETC., OF ST. CLAIR FLATS CANAL, MICHIGAN.

On August 5, 1891, the steamer *H. Chisholm*, of Cleveland, bound down, parted her wheel chains and ran into west pier, doing $47.14 damage.

On August 31, 1891, the barge *John Shaw*, of Hampton, bound down, in tow of steamer *J. F. Eddy*, of Hampton, had just entered the upper end of the canal, when the steam barge *A. Everett*, of Cleveland, tried to pass the *John Shaw*, causing her to sheer and strike the east pier, doing $56.84 damage.

On September 6, 1891, the steamer *City of Cleveland*, bound down, came into the canal when blocked at lower end by steamer *New Orleans* and barge *Light Guard*, which had been run into and sunk by the *Fontana*. The *City of Cleveland* stopped alongside of east pier and when she started out ran into the west pier, doing $47.98 damage.

On October 21, 1891, the steam barge *John E. Hall*, of Detroit, bound down, sheered and ran into the west pier, doing $23.26 damage.

On November 23, 1891, the steamer *James Pickands*, of Cleveland, bound down, tried to round to in the canal because the barge *John Shaw* had run into dredge *Ravenna* and blocked the canal at the lower end. The *Pickands* ran into the west pier, doing $40.97 damage.

On November 23, 1891, the steamer *Briton*, of Cleveland, came into the canal in face of the blockade made by dredge *Ravenna* and barge *John Shaw*, and had to stop alongside of the east pier, doing $55.83 damage.

On November 23, 1891, the barge *Harold*, of Hampton, in tow of steamer *Oneida*, bound down, came into the canal in the face of the *Sh*[illegible] and *Ravenna* blockade, and had to stop alongside of the east [illegible]ing $16.98 damage.

[illegible]ne 2, 1892, the steamer *R. P. Ranney*, of Cleveland, passed the [illegible] *H. D. Root*, of Cleveland, just after entering the upper end of [illegible]l, both boats being bound down. The suction from the *Ranney* [illegible]e *H. D. Root* alongside of her and then caused the *Ranney* to [illegible]o the east pier, doing $93.20 damage.

[illegible] furth[illegible]e, occupation, or injury to works in my charge than [illegible]ted are known to have occurred during the fiscal year [illegible]892.

[illegible]ctfully, your obedient servant,

O. M. POE,
Colonel, Corps of Engineers,
Bvt. Brig. General, U. S. A.

[illegible] THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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(6.) REPORT OF CAPTAIN DAN C. KINGMAN, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., August 26, 1892.

GENERAL: I have the honor to transmit herewith annual report upon the occupancy of and injury to public works in my charge by corporations or individuals during the fiscal year ending June 30, 1892.

I have the honor to be, very respectfully, your obedient servant,

DAN C. KINGMAN,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

HARBOR AT CHARLOTTE, NEW YORK.

There has been no new case of occupancy of the public works by corporations or individuals.

The public works at Charlotte, N. Y., have been twice injured by individuals during the past year as follows:

On or about the 13th day of October, 1891, the barge *W. Wheeler*, of Ogdensburg, in tow of the steamer *W. L. Proctor*, of the same place, struck against the west pier at Charlotte, N. Y., cutting through a number of timbers and damaging the pier to the extent of $73.26; also on or about the 20th day of October, 1891, the Canadian barge *Hiawatha*, of Kingston, in tow of the steamer *Chieftain*, of the same place, struck against the east pier and damaged it to the extent of $71.64. These injuries were promptly repaired by the United States; accurate account was kept of the cost of making the repairs, and this cost was taken as the measure of the damage done.

On the 14th day of December, 1891, by direction of the Chief of Engineers, the matter was placed in the hands of the United States attorney for the northern district of New York, and he was able, without suit, to collect from the parties full payment for the damage done. The total amount, $144.90, was remitted to me by the United States attorney, and was deposited to my official credit on the 26th day of February, 1892.

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APPENDIX A A A.

MAINTENANCE AND REPAIRS OF WASHINGTON AQUEDUCT—WATER SUPPLY, DISTRICT OF COLUMBIA—INCREASING THE WATER SUPPLY OF WASHINGTON, DISTRICT OF COLUMBIA—ERECTION OF FISHWAYS AT GREAT FALLS.

REPORT OF LIEUTENANT-COLONEL GEORGE H. ELLIOT, CORPS OF ENGINEERS, OFFICER IN CHARGE FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

1. Washington Aqueduct.
2. Water supply, District of Columbia.
3. Increasing the water supply of Washington, D. C.
4. Erection of fishways at Great Falls.

OFFICE OF THE WASHINGTON AQUEDUCT,
Washington, D. C., July 8, 1892.

GENERAL: I have the honor to transmit herewith report of operations for the following works in my charge for the fiscal year ending June 30, 1892, viz:

Washington Aqueduct.
Water supply, District of Columbia.
Increasing the water supply of Washington, D. C.
Erection of fish ways at Great Falls.

Very respectfully, your obedient servant,

GEORGE H. ELLIOT,
Lieutenant-Colonel of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

A A A I.

WASHINGTON AQUEDUCT.

Appropriations for the Washington Aqueduct are applied to the improvement, the maintenance, and repair of those portions of the Washington water supply, other than the tunnel, that have been placed under the supervision of the Chief of Engineers. The works include the masonry dam, 2,877 feet long, extending from the Maryland to the Virginia shore at Great Falls of the Potomac, 14 miles west of Washington; the works at Great Falls for regulating the supply of the con.

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duit; the conduit from Great Falls, 9 feet in diameter; the three reservoirs, viz, the receiving reservoir, about 4½ miles west of the city, the distributing reservoir, about 2 miles west of the city, and the high-service reservoir in Georgetown for the supply of the higher portions of that city; the mains by which the water is carried from the reservoirs and delivered into the city's distributing system, and the bridges for supporting the mains across Rock Creek.

The following statement exhibits the condition of the aqueduct and its accessory works and the operations of the last fiscal year.

THE DAM AT GREAT FALLS.

No damage has been done to the masonry dam at Great Falls during the last fiscal year and it is in excellent condition. Some of the riprap back of the dam, that was carried away by ice in the previous fiscal year, was not replaced during the last year by reason of the inadequacy of the appropriation for preservation and repair, and the pressure of more immediately important work.

THE CONDUIT AND THE CONDUIT ROAD.

The macadam pavement of the conduit road was generally placed over the conduit for its protection from the travel on the road, but there are exceptions to this rule, and with the view of discovering without too much expense the exact route of the conduit I have had uncovered during the year all of the 66 manholes between Great Falls and the distributing reservoir, and have had measured the distances from the manhole reference stones along the side of the road to the centers of the manholes. These distances have been recorded on the plats of the aqueduct for use whenever it may be found necessary to uncover and open any of the manholes for removing accumulations of deposits from the conduit or for making repairs. Nine of these reference stones were missing and I have had new ones cut and numbered and planted in their proper places.

When the water in the distributing reservoir is at its normal height of 146 feet above datum, there is a pressure of something over 4 feet of water on the crown of the conduit arch where it enters the reservoir, and the water in the conduit is backed up and the crown of the arch is under pressure about as far up as Griffith Park Bridge. I find that the tops of several of the casings of the manholes farther down the line are below the gradient, or slope of the water, so that when the manholes are uncovered it is found above the manhole covers and in some instances more than a foot in depth, as described in my monthly report for July, 1891. No harm has thus far resulted from this state of affairs, but the casings of the manholes wherever necessary (I have a record of them) should be raised above the gradient as soon as funds can be obtained for the purpose, so as to prevent the soakage of the ground around the manholes.

Nearly all of the water that falls on that part of the Potomac watershed that lies in Maryland and the District of Columbia between Great Falls and the distributing reservoir is carried in streams that flow under the conduit in 26 culverts, Culvert No. 1 being the next one below Great Falls and Culvert No. 26 being just above the distributing reservoir. Sand and bowlders carried down these streams in freshets lodge in some of these culverts that have small slopes, and a considerable portion of our work during the past year (as in every year) has

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been devoted to removing these deposits. Culvert No. 23 gives us more trouble than any of the others, and it is increased in this case by a dam that has been erected just below the boundary line of the United States land by the owner of the adjoining private property. I suspect that this case of backing sand and other detritus up under the culvert is a case similar to the illegal overflow of lands by the erection of dams, and that the removal of this dam will have to be brought about by the courts, for I have in vain endeavored to have the owner remove it to a point farther down the stream where it will be harmless.

The work of erecting strong guard fences for the protection of travel on the Conduit Road at the high embankments at the culverts has been continued. Three thousand two hundred running feet of these fences have been completed during the year, and this, with similar work in the previous year (7,464 feet, or about a mile and a half in all), has pretty nearly completed all of these fences required this side of Cabin John Bridge.

An improvement in controlling the water in the conduit and in the distributing resoirvoir has been made at Wasteweir No. 3. Grooves were cut in the sides of the weir for stop-planks, and the valve under the weir, which could formerly not be opened in great floods without endangering the life of the division watchman, was arranged to be conveniently and safely opened by means of a key.

An entirely new walk has been placed in the approach to Wasteweir No. 2. This weir is in Tunnel No. 4, and the approach to it is through a side tunnel which is always wet, so that the plank walk, which is elevated over the waterway from the weir, decays rapidly. The approach is a dangerous one, and especial pains were taken to use nothing for this purpose except the best Georgia pine that could be selected. One of the pair of waste gates or valves, built in the wall under this weir, has for many years been jammed so that it could not be opened. The cleaning out of the accumulation of deposits in Tunnel No. 4 has enabled the trouble with this gate to be removed, so that it is now restored to use and enables me to empty the conduit when required much more rapidly than before.

For several years there has been a serious leak from the conduit at Wasteweir No. 1, just this side of Great Falls. It was caused by the decay of the wooden frames of the two waste gates that are built into the wall under this weir. Occasion has been taken of the emptying of the conduit during the work of removing the deposits from Tunnel No. 1, in the side of which this wasteweir is, to replace the frames of the gates by new ones, and the leak has been stopped.

Access from Great Falls, where the division watchman lives, to this wasteweir, which opens from Tunnel No. 1, in the face of a bluff overlooking the Chesapeake and Ohio Canal, has always been difficult, and at night, especially in times of freshet and ice, dangerous. It is one of the most important of the wasteweirs on which the safety of the aqueduct largely depends, and I have had excavated an easy pathway extending around the hill from Great Falls to this wasteweir.

The macadam pavement of the Conduit Road has been repaired at several places during the year. Pains are taken not to allow it to be worn so much as to endanger the conduit, which it protects, but I can not keep the road in as good order as is desirable for travel by reason of the limited amount of the annual appropriations for repairs. The Conduit Road, which is mainly beyond the Maryland line, is, by reason of its scenery and easy grades, the finest road leading out of the District, and is worthy of a special appropriation for its improvement and

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adornment, by sodding of the slopes of the embankments along the route, etc., but as this work is not strictly necessary for the purposes of the aqueduct I do not make an estimate for it.

An outlet from the 9-foot by-conduit at the receiving reservoir, controlled by a 10-inch valve, which was covered up when the spillway was constructed in 1885, has been restored to use in emptying the conduit, by casing the valve and laying 90 feet of surplus 12-inch cast-iron pipe obtained from the new reservoir near Howard University.

The feeder at the head of the conduit at Great Falls has been cleaned out several times during the year. There seems to be a draft of sand and other material into the conduit during the operation of putting down the stop planks whenever the conduit is emptied. There is no remedy for this, except by dredging outside the mouth of the feeder.

In subdividing the land purchased by syndicates between the distributing and receiving reservoirs several new streets have been opened northward from the Conduit Road, and are a damage to the road by reason of the great quantities of earth and clay that are washed down these streets and cover the pavement of the road. Another trouble arises from the obstruction of the proper drainage of the Conduit Road by carrying the streets across and filling up the gutters along the road. The major part of these troubles could be easily avoided by the owners of the land, and if they allow them to continue I shall ask authority to fence off these streets from the Conduit Road.

I have found during the cleaning out of the 9-foot by-conduit at the receiving reservoir that for a distance of 615 feet the lining of the tunnel under Dalecarlia Hill (Tunnel No. 5) is but 8 feet in diameter. The by-conduit was constructed during the late civil war, when the aqueduct was temporarily in charge of the Department of the Interior. The records of the time show that the bore of the tunnel was 11 feet in diameter, but there is no record showing the variation of the interior diameter of the lining of the tunnel from the diameter of the main conduit with which it connects at both ends of the tunnel, or why a reduction was made. The result of it is that the full capacity of the aqueduct can only be obtained when the water is allowed to flow through the receiving reservoir itself and not through the by-conduit. In mentioning in my monthly report for May, 1892, the discovery that the by-conduit tunnel is only 8 feet in diameter, I stated the capacity of an 8-foot conduit as given by the formula under the following circumstances: First. When the water at the head of the conduit is at the height of 6 inches over the aqueduct dam (which may be considered the summer flow of the river), and the water in the distributing reservoir is at the height of 146 feet above datum. Second. When the water is at the height of the intrados of the conduit arch, both at the head of the conduit and at the distributing reservoir.

Inspection of the conduit.—As stated in my last annual report, there had been for some years a serious leak from the conduit on the southerly side, just west of Cabin John Bridge. I do not know when it was first discovered, but since I have had charge of the aqueduct it had flowed from 30,000 to 40,000 gallons a day. The point of discharge was just at the end of the west abutment of the bridge, leading to the supposition that a crack existed in the conduit where it left the compressible foundation on the embankment at the end of the bridge, and passed to the incompressible abutment.

To enable me to investigate the source of this leak and repair it, and at the same time to inspect the interior of the conduit. which had not been done for many years, and especially the tunnels, I made arrange-

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ments for a complete emptying of the conduit and for its inspection from Great Falls to the distributing reservoir, to take place on the 1st of September.

The following manholes along the line were opened during the two days before the inspection, viz: Nos. 1, 9, 15, 19, 21, 27, 30, 33, 38, 39, 41, 43, 52, and 56, the manhole just above the north connection at the receiving reservoir, the two manholes in the 9-foot by-conduit at this reservoir, and the manholes in bridges 1, 2, and 3.

Wherever these manholes were on the Conduit Road, which was the case with nearly all of them this side of the hill where the road to Great Falls leaves the Conduit Road, they were strongly fenced and lighted at night to prevent travelers along the latter road from driving into them.

The conduit was divided into sections. The first two sections embraced the major part of the Maryland portion of the conduit. Section No. 1 extended from Great Falls to Bridge No. 3 (Griffith Park Bridge), and Section No. 2 extends from Bridge No. 3 to Tunnel H, or just beyond Dalecarlia Hill. Section No. 3 embraced that part of the conduit which lies between Tunnel H and the distributing reservoir.

Two men, to be provided with lanterns and rubber clothing, were assigned to go through each section. Men with carts, carrying ladders, extra lanterns, oil, and their provisions for the day, were to follow along the road and communicate with the men inside the conduit from manhole to manhole. There were also parties which were to follow the carts, remove the fences, replace the manhole covers, refill over them, and restore the roadway.

I went to Cabin John Bridge the night before to superintend in person the repair of the leak in the conduit at that place as soon as the water would permit, which I hoped would be by 5 or 6 o'clock in the morning. The inspectors of all the sections of the conduit were to report to me at that place as soon as their inspections should be completed.

It was my intention to empty the conduit through the two waste gates at Wasteweir No. 1, which is at the outlet from Tunnel No. 1, near Great Falls, and which discharges into the Chesapeake and Ohio Canal; through one of the waste gates at Wasteweir No. 2, which discharges from Tunnel No. 4, near the receiving reservoir, into Little Falls Branch, which passes under the Chesapeake and Ohio Canal in a culvert (the other gate of the pair of gates under this weir had not been in working order for many years), and from the waste gate at Wasteweir No. 3, near the distributing reservoir, the water from which is also discharged under the canal, but late in the evening the gatekeeper at Great Falls telephoned me that a leak in a newly-repaired bank of the canal below the falls had been discovered, and that it would not be safe to open the gates at Wasteweir No. 1. This was extremely disappointing, for I had made all the arrangements to commence the emptying of the conduit at midnight and for the inspection the next day, and it would make a considerable loss of money not to go on with it. On the other hand, to continue without the use of the two gates at Wasteweir No. 1, through which I expected to discharge at least half of the contents of the conduit (about 30,000,000 gallons), would about double the time required for emptying it and delay the commencement of the inspection. I concluded to go on, using the short piece of conduit leading to the new tunnel from the 7-foot by-conduit at the auxiliary connection at the distributing reservoir, which, in part, would compensate for the loss of the use of the two gates at Wasteweir No. 1.

At 10:30 p. m., therefore, on the night of the 31st of August, the stop planks at the inlet to the feeder of the conduit at Great Falls and at the

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influent gatehouse at the distributing reservoir were commenced to be put down as had been originally arranged. They were in place at midnight. The gate at Wasteweir No. 3 was opened at 12:30 a. m. on the 1st of September, and at 1 a. m. the gate at Wasteweir No. 2 and the connection between the 7-foot by-conduit at the distributing reservoir and the new tunnel were opened.

The 12-inch main from the distributing reservoir was used as a drain into Foundry Branch to prevent the water from the reservoir backing up into the 7-foot by-conduit through the leaks which exist in the gates in the old auxiliary connection.

The water in the conduit dropped off rapidly for the first 3 feet of its depth, but after that it fell slowly by reason of leaks in the stop planks between the conduit and the two reservoirs.

It was 8 o'clock a. m. before the gate keeper at Great Falls, Mr. Sullivan, with his companion, could enter the conduit for the inspection of section No. 1, which he did through the feeder. He went through the conduit and all the tunnels to Bridge No. 3.

It was 2 o'clock p. m. before Mr. Ferguson, the valve tender and machinist, with a companion, to whom I assigned the Section No. 2, could enter the conduit. I found that by reason of the delay, and the difficulty of walking through the deep mud, he would barely be able to reach Cabin John Bridge by night, and I assigned in the afternoon the inspection of the portion of the conduit between Cabin John Bridge and Griffith Park Bridge to two intelligent workmen belonging to the receiving-reservoir division.

For the inspection of Section No. 3 the gate keeper at the distributing reservoir, Mr. Harrington, succeeded in getting a boat into the south connection at the receiving reservoir at 10:30 a. m. and passed through the 9-foot by-conduit, Tunnel No. 4, the conduit between this tunnel and Tunnel H, to Manhole No. 51. Mr. Smead, the superintendent, accompanied him in this part of his inspection. Mr. Harrington then returned by the same route to the south connection and passed, also by boat, from it through the conduit and the 7-foot by-conduit of the distributing reservoir to the auxiliary gatehouse at this reservoir.

At 6 o'clock p. m. the inspection of the entire conduit had been completed. The manhole covers were replaced, and at 11 o'clock p. m. the stop planks at the mouth of the feeder at Great Falls were raised, and the water from the river was turned into the conduit. The gate at Wasteweir No. 2 was left open until 2 a. m. of the 2d to allow the mud stirred up by tramping through it to be carried off, when it was shut, and by noon of that day the water on the conduit side of the stop plank between the distributing reservoir and the conduit having raised to the height of the water in the reservoir, the stop planks were raised and the water flowed again into the reservoir.

At Cabin John Bridge I found that the leak did not come from a crack at the place I anticipated it would be, but from one in the northerly side of the conduit, between Manhole No. 38 and the bridge, commencing about 8 feet below this manhole and extending about 40 feet towards the bridge. The major portion of it was about three-quarters of an inch wide, and the water issuing from it must have passed down the outside of the conduit to the abutment of the bridge, then under the conduit to the place of exit, where it flowed into the creek, as I have before stated, on the southerly side of the bridge.

The mason whom I had engaged and sent to the bridge the night before carefully repaired the break in the conduit arch with the quick-setting cement provided for the purpose, and it was completed by the

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time the inspection of the conduit was finished. The next morning there was no sign of water at the old outflow of the leak nor has any appeared since.

Results of the inspection.—For the reason, probably, that there had not been found any previous necessity like the one occasioned by the leak above Cabin John Bridge for emptying the conduit of its (about) 30,000,000 of gallons of water, and the consequent cutting off of the supply from the Potomac at Great Falls for a considerable time, I can find no account of any former inspection of the interior of the conduit since the Potomac water first commenced to run through it, nearly thirty years ago. I think it advisable, therefore, for future reference to state somewhat in detail the result of my inspection of September 1, 1891.

The Potomac water being so often muddy, it might have been anticipated that the accumulation of deposits in the conduit would have been considerable, but I was surprised to find it as great as it was, especially in Tunnel No. 4 and in the 9-foot by-conduit at the receiving reservoir.

Commencing at Great Falls, the depths may be stated as follows:

From the gate house to Wasteweir No. 1 the mud was about 24 inches deep; through Tunnel No. 2 it was about 18 inches deep; from Tunnel No. 2 to Tunnel No. 3 it was about 10 inches deep; through Tunnel No. 3 it was about 24 inches deep; from Tunnel No. 3 to Tunnel F it was from 10 to 20 inches deep; through Tunnels F and G it was about 24 inches deep; between Tunnels F and G it was about 16 inches deep; between Griffith Park Bridge (Bridge No. 3) and Cabin John Bridge (bridge No. 4) it was from 12 to 16 inches deep; between Cabin John Bridge and Tunnel H it was from 1½ to 2 feet deep. Between Tunnel H and Tunnel No. 4 it was about 1½ feet deep. In Tunnel No. 4 and in the conduit between the lower end of this tunnel and the north connection at the receiving reservoir it was about 4 feet deep; in the 9-foot by-conduit which passes around a portion of the receiving reservoir it averged about 3 feet deep, and at the upper end just below the north connection it was about 4½ feet deep. In the conduit between the receiving reservoir and the distributing reservoir was found the least depth of deposit. It was mainly between Wasteweir No. 3 and the influent gatehouse, and averaged about 6 inches deep.

The following are the estimates of the quantities of deposit in cubic yards found in the different portions of the aqueduct, and an estimate of the total quantity:

	Cubic yards.
Between Great Falls to Bridge No. 3	5,724
Between Bridge No. 3 and Cabin John Bridge	1,580
Between Cabin John Bridge and Tunnel H	4,385
Between Tunnel H and Tunnel No. 4	729
In Tunnel No. 4	633
In the 9-foot by-conduit at the receiving reservoir	1,857
Between the receiving reservoir and the distributing reservoir	515
Total between Great Falls and the distributing reservoir	15,423

I should also remark that in the 7-foot by-conduit at the distributing reservoir, which I thoroughly cleaned the year before, there was found a considerable deposit, especially at the end near the influent gate house, where it is about 1½ feet deep.

In addition to these deposits there were found the following:

About 50 feet below the gates in the gate house at Great Falls, a bank of deposits about 4 feet deep and extending about 25 feet down the conduit.

About 50 feet below manhole No. 1, at Great Falls, a fall of about 6 cartloads of rock from the roof of Tunnel No. 1.

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About 400 feet above Waste-Weir No. 1, about 20 cartloads of rock from the roof of the same tunnel, piled to a depth of about 4 feet.

An old self-acting guard gate in the conduit between the north connection at the receiving reservoir and Tunnel No. 4. It was constructed of white pine, 8 inches thick and hung horizontally at the top, but the pivot at one end had decayed, leaving the gate dropped down on that end, obstructing the flow of water. The major part of the gate was rotten and it was altogether useless. I have since had it removed and it should be replaced, but it will be expensive, and the annual appropriation for preservation and repair of the aqueduct, unless increased, will not be able to bear the cost of it.

About 75 feet below the four ventilators in the conduit near the receiving reservoir, a vertical iron rod, 1½ inches in diameter, the purpose of which is unknown. It was fastened at top and bottom in the conduit arch.

Three manholes at Bridge No. 3, that have been closed up and do not appear in the floor of the bridge. They were probably sealed up and covered when the floor of the bridge was asphalted, in 1872 or 1873, and I think it was a mistake. Gen. Meigs, as I find in old reports, covered them with wooden covers, which would be lifted and carried away in case that any accident or neglect should cause an overfilling of the conduit. They were for the same purpose as the four ventilators in the conduit just below the receiving reservoir.

I especially directed that the interior of the conduit should be observed to discover cracks in the conduit arch and to locate them with reference to the manholes, so that from the reports I would be able to locate the cracks, if any existed, with reference to the culverts.

There were several cracks found, but before giving a list of them it should be stated that they are mostly at the culverts, and were no doubt caused by settlements of the conduit where it was built on high embankments soon after its construction. None of the cracks leak except the one at Culvert No. 26, where water has been discovered by the division watchman issuing through the side of the culvert side walls, and from none of them is any danger to the conduit to be aprehended. They can all be thoroughly repaired if the appropriation for preservation and repair be increased by $1,000 as I have asked. The masonry, constructed by the late Gen. Meigs, was everywhere found to be of excellent quality, and greatly in contrast with the short piece of the conduit which passes around the receiving reservoir, which is termed the 9-foot by-conduit, and was constructed during the late war, when the aqueduct was temporarily in charge of the Department of the Interior.

The following is a list of the cracks:

About 225 feet above Manhole No. 5, a crack about 75 feet long. About 140 feet above Manhole No. 6, a crack about 120 feet long. This crack is over Culvert No. 1. It was probably caused by the root of a tree found in the crack, which split the conduit arch after penetrating a joint. The root was cut off. About 30 feet above the manhole in Bridge No. 1, a crack about 6 feet long. A root was cut out of this also. About 50 feet above Manhole No. 34, a crack about 75 feet long. This is over Culvert No. 16. A crack extending about 60 feet above and about 175 feet below Manhole No. 40. This is over Culvert No. 18. A crack commencing near Manhole No. 46 and extending about 150 feet towards Manhole No. 45. It, like most of the others, is on the top of the arch, which is of stone at this place. This is over Culvert No. 20. Several cracks, probably only in the plaster lining, between Manholes Nos. 51 and 53. A crack near Manhole No. 57. Several small cracks near Manhole No. 58. Several cracks between Manholes Nos. 58 and 59. One is about 75 feet long and is about over Culvert No. 23. A few cracks between Manholes Nos. 59 and 60. Several cracks between Manholes Nos. 60 and 61. Culvert No. 24 is between these manholes. Several cracks near Manhole No. 62. Several small cracks near Manhole No. 63. Several

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cracks between Manhole No. 64 and Waste Weir No. 3. One is about 100 feet long. It is over Culvert No. 25. A crack 30 feet long about 150 feet below Waste Weir No. 3. Several cracks between Manholes Nos. 65 and 66. One is about 150 feet long and more open than any found in this part of the aqueduct. It is over Culvert No. 26.

The old drawings in this office are not definite in all cases in respect of linings of the tunnel. Danger may be apprehended in an unlined tunnel from slips of rock from its roof or sides. It was found that Tunnel No. 1 is not lined on the sides and bottom, but is arched with stone resting on natural-rock side walls. Tunnels Nos. 2 and 3, F and G, are not lined. Tunnels B, C, D, E, and H, are lined with brick. Tunnel No. 4, under Dalecarlia Hill, is unlined, except at Waste Weir No. 2, where it is lined with stone, and at a point about 50 feet below this weir, where there is about 30 feet of lining of brick. The tunnel in the 9-foot by-conduit (Tunnel No. 5), with the exception of two gaps in the lining where the rock is solid, is lined with brick. The remainder of this by-conduit is constructed of stone.

The number of men employed in emptying and refilling the conduit and during the inspection, not including regular employes, was 27, and the total cost, including carts, uncovering, fencing, and re-covering manholes and refilling over them, and including also the repair of the conduit at Cabin John Bridge, was $196.75.

The removal of the deposits.—The work of removal of the deposits from the conduit was commenced in November last and has been continued from time to time as the condition of the river and the funds available for the work permitted. The plan that I have adopted for this tedious and expensive work as most economical and expeditious, and the only one that is practicable with the small annual appropriation for preservation and repair of the aqueduct, is to loosen up the compacted deposits by shovels and hoes and then to turn on the water and run the mixture through the waste gates at Waste Weir No. 2, in Tunnel No. 4. For the work in Tunnel No. 4 and in the by-conduit at the receiving reservoir the sluicing is done with the water of the receiving reservoir, turning it in at the south connecion. For the work in the conduit above Tunnel No. 4 the sluicing is done with water from Great Falls, and I find that under a full head of water at the falls, and with both the waste valves under Waste Weir No. 2 opened wide, we have a scouring velocity in the conduit of about 5 feet per second. The work is carried on in eight-hour shifts, working night and day, and is continued until the consumption and waste of water in the city has reduced the height of the water in the distributing reservoir so much as to make it necessary to stop the work and again turn on the water at Great Falls. When the work is going on the distributing and receiving reservoirs are made one reservoir by raising the stop planks that separate the receiving reservoir from the conduit at the south connection and transferring them to the grooves at the lower end of the by-conduit. The distributing reservoir is then cut off from all supply of water except what can be furnished from the receiving reservoir and the small streams that empty into it. It has been found that each period of working in the conduit can not, as a general rule, be extended more than sixty hours, and as it requires from four to five days after turning on the water at Great Falls and filling the conduit to raise the water in the distributing reservoir again to its normal height of 146 feet above datum, sixty hours in each week may be considered as about the amount of time that can be devoted to the work of cleaning out the conduit when money can be had for the purpose and the state of the river at Great Falls will allow. At the end of the fiscal

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year the cleaning out of Tunnel No. 4, the 9-foot by-conduit (in which were found several boatloads of stones, bricks, pieces of concrete, and a great many poles and some planks), and the conduit above Tunnel No. 4, for a distance of about 1,200 feet, in all about 4,500 feet, as well as Tunnel No. 1, near Great Falls, as far down as Waste Weir No. 1, has been nearly completed. The whole length of the conduit from Great Falls to the auxiliary gate house at the distributing reservoir being about 63,000 feet, or about 12 miles, there remains to be cleaned out about 58,500 feet of conduit. The annual appropriations for the maintenance and repair of the aqueduct, and the reservoirs, mains, roads, etc., connected with it, are so small that the work of removing the deposits can not be done without neglect of other necessary work, and even with this neglect, to finish the work by means of these ap-appropriations would require many years. A special estimate of $14,000, which would enable the entire conduit to be cleaned out in one year, is included in the estimates for the next fiscal year.

THE RESERVOIRS.

I found that in exceptional storms the floods from Little Falls Branch and the two other streams that empty into the receiving reservoir, overflowed the walls that form the sides of the open chambers known as the north connection and the south connection; that at such times the conduit above and below the reservoir, as well as the by-conduit, were subjected to a pressure of water several feet higher than was contemplated, and, what was of more importance, that a large part of the great accumulation of silt that I found in Tunnel No. 4 and in the by-conduit, when I inspected the conduit, had at such times undoubtedly been drawn into them from the north connection, into which the silt had been carried with the water from Little Falls Branch, the mouth of which is quite close to this connection. To remedy these serious evils I have had the walls that form the sides of both these open chambers raised 2 feet 8 inches.

Three pillar cranes that were purchased for the reservoirs from the appropriation for preservation and repair for the fiscal year 1890–'91 were erected during the last year. They are for handling the heavy stop timbers and were placed, one at the north connection and one at the south connection of the receiving reservoir, and the other at the cut through the cross dam at the distributing reservoir. These, with the two others which were purchased at the same time and have been placed at the head of the conduit at Great Falls, work with great facility and have proved very convenient and useful.

On the morning of the 23d of February, while the by-conduit was empty and was being cleaned out, water from the receiving reservoir was found forcing its way through the bottom of this conduit at a point about 10 feet below the north connection. The leakage, which was extensive, caused the earth and riprap protection of the conduit between it and the reservoir to sink to a depth of several feet, but the exposure of the conduit was prevented by the débris from Little Falls Branch that had shoaled the upper part of the reservoir. A temporary dam was built to keep the water of the reservoir away from the spot, the riprap was taken out and replaced, and the cavity filled with clay. The safety of the by-conduit at this point when the waterway between the north connection and the receiving reservoir is excavated to the required depth will necessitate the construction of a substantial retaining wall 75 feet to 100 feet long, between the conduit and the reservoir,

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but it will have to be deferred until an appropriation for improving the reservoir can be obtained.

During the last year, when the work of removal of the deposits from the conduit was going on, and also at the times of low water in the Potomac last summer, I was obliged to reinforce the distributing reservoir by the water of the receiving reservoir and the three streams that flow into it.

A self-registering tide gauge, kindly loaned for the purpose by Prof. Mendenhall, Superintendent of the Coast and Geodetic Survey, has been placed in the screen house at the distributing reservoir for the purpose of recording the fall of water in the reservoir at the times of cleaning out the conduit.

A new floor was placed in the sluice tower at the receiving reservoir, and alarm bells for night use connecting with the telephone line to this office were placed upstairs in the houses of the watchmen at the reservoirs and at Great Falls.

THE MAINS.

The trunk mains that lead from the distributing reservoir and supply the distributing system of street mains were, as a general rule, laid by the United States, and are under the care of this office. The aggregate length of these mains is about 20 miles. The distributing mains were laid by the District of Columbia and are under the care of the Commissioners of the District.

There have been no serious leaks in the trunk mains during the last fiscal year, and only one break. This was in the 24-inch main in K street east, between First street east and Delaware avenue. It was not an extensive one and at my request it was repaired by the city authorities.

It was found that the temporary flume that was constructed to carry off into Rock Creek the flow from the 20-inch blow-off on the 48-inch main at M Street Bridge during the monthly flushing of this main, was inadequate for the purpose. I therefore extended the blow-off to the creek by means of 63 feet of 20-inch cast-iron pipe, its outlet being so arranged that the water discharged from the blow-off (it has about 100 feet of head at this place) would not wear away the banks of the creek.

The flood of the 5th of September last considerably damaged the blow-off from the 36-inch main in its passage through the culvert under the canal at Foundry Branch, and uncovered the 36, 30, and 12 inch mains where they cross that stream. The blow-off was repaired and the covering of the mains was carefully replaced.

By authority of the Chief of Engineers, the District government reinforced at Thirty-second street the 12-inch main by a 12-inch connection with the 36-inch main, for the better supply to the Georgetown pumping station on Q street, between Thirty-second and Thirty-third streets, and a valve was placed on the 12-inch main east of the connection.

The lines of trunk mains have been carefully inspected and flushed out monthly, and the valves have been regularly oiled and cleaned during the year.

THE AQUEDUCT LANDS.

I have had a careful and complete survey of the lands pertaining to the receiving reservoir made during the year by Mr. Brewer, deputy

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surveyor of the District of Columbia, and one copy of the plat was sent to the Chief of Engineers. Copies have also been sent for record at the offices of the surveyor of the District of Columbia and the circuit court at Rockville, a part of the land being in the District and a part in Montgomery County, Md.

The complete survey of the Conduit Road lands, which was commenced during the fiscal year 1890–'91, by Mr. Smead, the superintendent of the aqueduct, has been continued during the last fiscal year as time could be spared from his other duties. This survey was made necessary by the fact that while the north side of the Conduit Road lands was marked by monuments by Gen. Meigs when he purchased the lands in the years 1853–'57 for the United States, the south side was not so marked, and in the rapid improvements now being made along the line of the aqueduct encroachments are liable, by reason of errors of surveyors in laying off and subdividing the contiguous private lands unless such monuments everywhere mark the United States lands. This survey has been completed to a point this side of and near Griffith Park Bridge. One hundred and eighty-nine monument stones have been cut and lettered to mark the angles on the lines of survey, and thirty-one of them have been planted.

Surveys were made of a portion of the boundaries of the United States lands near Great Falls and of some pieces of land on and beyond Dalecarlia Hill, projecting from the Conduit Road and reservoir lands.

In my investigations of the titles to the aqueduct lands I found that the title papers of several parcels of these lands were neither in the land files at the Department nor in this office, and had probably been either lost or mislaid in the changes that were made in the custody of the aqueduct papers to and from the Department of the Interior and to and from the office of the Commissioner of Public Buildings and Grounds. I have, therefore, procured from the land records of the District of Columbia and of Montgomery County, Md., copies of missing papers pertaining to eighteen parcels of land, and the copies in this office of all the titles to aqueduct lands that are known to exist are now complete. I also found that, about twenty years ago, the title papers to six parcels of land in Montgomery County, Md., were erroneously recorded in the land records of the District of Columbia and that two parcels of land in the District were erroneously recorded in the land records at Rockville. The originals of these papers have been procured from the Department and they have been recorded in their proper places.

In the clearing of the ground over and near the conduit of trees, to prevent their roots from penetrating and splitting the conduit arch, I have saved a large number of locust posts, and have purchased about 20,000 feet of lumber for completing the fencing of the lands pertaining to the receiving reservoir as soon as funds can be spared for the purpose.

THE BRIDGES.

With the exception of the bridge over the Spillway from the receiving reservoir, the bridges are generally in good condition, except in respect of their pavements. There are some small leaks in the conduit in its passage over Cabin John Bridge, which are shown by drippings from the arch, but they can not be repaired before I obtain funds for removing the accumulation of deposits in the conduit.

Such repairs as could be made have been made on the bridge over

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the Spillway from the receiving reservoir and in the pavements of the masonry bridges. The flooring of the Pennsylvania Avenue Bridge over Rock Creek will be renewed from the appropriation for preservation and repair in the fiscal year just commenced.

A new bridge of masonry is needed where the Conduit Road crosses the Spillway at the receiving reservoir, the old wooden bridge at that point being unsafe for the heavy travel on this road, and a special estimate for it is submitted in my annual estimates.

The asphalt pavements of Griffith Park and Cabin John bridges (bridges Nos. 3 and 4), which were laid many years ago, are in very bad condition and should be replaced by durable pavements of granite blocks, for which a special estimate is submitted.

Measurements of the daily supply to the city.

Hourly and total flow from distributing reservoir for the twenty-four hours ending at 6 a. m., June 25, 1892. City temperature, in the shade, at 2 p. m., June 24, 89°.

Date.	Outflow per hour.	Date.	Outflow per hour.
June 24—	*Gallons.*	June 24—	*Gallons.*
From 6 a. m. to 7 a. m	1,824,111	From 8 p. m. to 9 p. m	1,655,809
From 7 a. m. to 8 a. m	2,102,059	From 9 p. m. to 10 p m	1,378,587
From 8 a. m. to 9 a. m	1,959,692	From 10 p. m. to 11 p. m	1,377,377
From 9 a. m. to 10 a. m	1,677,623	From 11 p. m. to 12 midnight	1,513,684
From 10 a. m. to 11 a. m	1,955,085	June 25—	
From 11 a. m. to 12 noon	2,370,917	From 12 midnight to 1 a. m	1,374,910
From 12 noon to 1 p. m	1,810,659	From 1 a. m. to 2 a. m	1,648,227
From 1 p. m. to 2 p. m	1,947,815	From 2 a. m. to 3 a. m	1,234,877
From 2 p. m. to 3 p. m	1,945,147	From 3 a. m. to 4 a. m	1,371,075
From 3 p. m. to 4 p. m	1,665,506	From 4 a. m. to 5 a. m	1,369,862
From 4 p. m. to 5 p. m	2,079,516	From 5 a. m. to 6 a. m	1,505,442
From 5 p. m. to 6 p. m	1,938,240		
From 6 p. m. to 7 p. m	1,659,565	Total	41,161,780
From 7 p. m. to 8 p. m	1,795,995		

Measurements of the consumption and waste of water in the city in the last fiscal year.

Date.	Gallons.	Date.	Gallons.
Friday, July 31, 1891	39,835,062	Wednesday, May 25, 1892	38,181,821
Monday, February 22, 1892	38,266,149	Monday, June 6, 1892	40,421,982
Tuesday, April 19, 1892	37,775,201	Tuesday, June 14, 1892	41,143,966
Thursday, May 12, 1892	37,215,317	Friday, June 24, 1892	41,161,780

Consumption and waste of water in the city, as measured annually in the latter part of June of each year, from 1874 to 1892, both inclusive.

Year.	Gallons.	Year.	Gallons.	Year.	Gallons.
1874	17,554,848	1881	26,525,991	1887	26,878,424
1875	21,000,000	1882	29,727,864	1888	29,115,774
1876	24,177,797	1883	24,314,715	1889	27,708,779
1877	23,252,932	1884	24,827,113	1890*	35,541,845
1878	24,885,945	1885	25,219,194	1891	38,594,743
1879	25,947,642	1886	25,542,476	1892	41,161,780
1880	25,740,138				

* Forty-eight-inch main added to the supply.

The total population of Washington and Georgetown at the last census (1890) was 202,978. Dividing this number into the total daily amount of Potomac water consumed and wasted in the last fiscal year,

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as given by the average of the measurements taken during the year, the daily average per capita is found to be 193.4 gallons. The census found, however, that 15,978 of the population of the two cities lived outside of the area supplied with Potomac water. Deducting this number from the total population, and using the remainder, 187.000, as a divisor, we find the daily average per capita within this area to be 209.9 gallons.*

It will have been observed that the dates of measuring the consumption and waste of water in the city during the last fiscal year were quite irregular. The reason for this was that I deemed it best, while the Potomac was either at its low stage or very muddy, not to lower unnecessarily the head of water in the distributing reservoir. This reduction of head could not be avoided when we were removing deposits from the conduit, and the major part of the measurements were taken at these times.

MISCELLANEOUS.

In addition to the foregoing work of the last fiscal year stated under the appropriate headings, the telephone line between the head of the aqueduct at Great Falls, the reservoirs, and this office has been frequently repaired. It has been in use since 1873; it is about worn out, and a new wire is urgently needed. A new gauge made for use in Manhole No. 1 (which is the next manhole below the gates that control the flow of water into the conduit at Great Falls) enables us to regulate with more facility the operations of these gates. The removal of ice that obstructed the flow of water into the feeder at Great Falls and into the screen house at the distributing reservoir was required several times during the winter. A large shed for sheltering the heavy pipe wagon used in cases of breaks in the mains, and the other wagons and carts used in the aqueduct service, was erected in the office yard, and all of the buildings in the yard were repaired and painted. Repairs were made at the high-service reservoir in Georgetown, the dwellings of the division watchmen, the office building, and the fences on the lines of the aqueduct lands.

On reference from the Chief of Engineers, reports on the following bills introduced in the Fifty-second Congress, first session, have been made by me during the fiscal year:

S. 804, to incorporate the Washington and Great Falls Electric Railway Company. (Two reports.)

H. R. 2765, to incorporate the Georgetown, Arlington and Falls Church Railway Company of the District of Columbia.

H. R. 3591, to authorize the Norfolk and Western Railroad Company of Virginia to extend its line of road into and within the District of Columbia, and for other purposes.

S. 1702, to amend an act entitled "An act to incorporate the Washington and Western Maryland Railroad Company."

S. 2045, to provide for the rebuilding of the bridge across Rock Creek at M street northwest, in the District of Columbia.

H. R. 5353, to incorporate the East Washington Crosstown Railway Company of the District of Columbia.

H. R. 5445, to repair the bridge across Rock Creek at M street northwest.

S. 1046, to amend the charter of the Eckington and Soldiers' Home Railroad Company.

H. R. 410, to amend the charter of the Eckington and Soldiers' Home Railroad Company.

S. 2015, to amend the act incorporating the Washington and Georgetown Railroad Company.

* These calculations exclude the increase (unknown) in population since 1890.

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H. R. 429, to incorporate the District of Columbia Suburban Railway Company.
S. 2174, to incorporate the Crosstown Railroad of the District of Columbia.
S. 2405, to incorporate the East and West Washington Traction Railway Company of District of Columbia.
S. 2496, to incorporate the Union Passenger Railway Company of the District of Columbia.
S. 2611, to authorize the Glen Echo Railroad Company to cross the Washington Aqueduct.
H. R. 7315, to authorize the Glen Echo Railroad to cross the Washington Aqueduct.

NECESSITY FOR FURTHER APPROPRIATIONS.

It is my duty to call especial attention to several works that are urgently needed. Most of them were mentioned in my last annual report.

IMPROVING THE QUALITY OF THE WATER SUPPLY.

Now that the city is everywnere abundantly supplied with water, except at a few points where its proper distribution is interfered with by the small size and the reduction in capacity by internal corrosion of the city's street mains and the service pipes leading from them to residences, one of the most important works to be done in connection with the aqueduct is to furnish the city with better water; or, since the water of the Potomac as brought from Great Falls is, I am convinced, perfectly wholesome at all times, it would be more correct to say with clearer water.

The muddiness of the water supplied to the city arises from the earthy matter carried down to the upper Potomac and its tributaries in storms and most abundanty in winter and early spring, by reason of the alternate freezing and thawing of the ground.

The following table gives the number of days in the four years ending June 30, 1889, on which the water had different degrees of turbidity at Great Falls:

Fiscal year.	Clear.	Slightly turbid.	Turbid.	Very turbid.
1885-'86	127	36	51	151
1886-'87	164	29	51	121
1887-'88	194	15	26	131
1888-'89	147	33	50	135
Average for four years	158	28	44	134

The following table gives the number of days in the four years ending June 30, 1889, on which the water had different degrees of turbidity at the effluent gatehouse at the distributing reservoir, after passing through the reservoir to the mains leading to the city:

Fiscal year.	Clear.	Slightly turbid.	Turbid.	Very turbid.
1885-'86	147	35	72	111
1886-'87	256	39	32	38
1887-'88	240	16	52	58
1888-'89	193	24	64	84
Average for four years	209	28	55	73

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It will be observed that the total time that the water was "turbid" and "very turbid" at the distributing reservoir was only about two-thirds of the total time that it was "turbid" and "very turbid" at Great Falls, and this great improvement in the water supplied to the city, as compared with its condition when it entered the conduit, was due to the time, short, as it was, given for depositing its earthy (clayey) matter in the distributing reservoir.

Filtering the water consumed by the cities of Washington and Georgetown would be enormously expensive (it has been estimated that the first cost of filtration works would be from $600,000 to $800,000, and the annual cost from $18,000 to $43,000, according to the plan adopted). We have now no "head" to spare for it, and we can get no head for it without pumping.

Except by pumping there can be no filtration without loss of head that we now have, and for every foot of head lost in our case there would be a belt of Capitol Hill and a belt of the northern portion of the city that would be deprived of the water that is now supplied to them.

Turbidity does not necessarily make waters unwholesome. The clearest waters are sometimes the most dangerous, because they are deceptive, and filtration can, at most, only make waters clear.

During the times of its turbidity the Potomac water has caused resort to the clear but deceptive well waters of the city for drinking purposes, and they doubtless have caused disease which has been attributed to Potomac water, and when the Potomac water has been allowed to flow through the receiving reservoir and mingle with the water of this reservoir there have been complaints of it, but the Potomac water by itself, as brought directly from Great Falls, has never, even in its worst condition, been proved to be unhealthful; on the contrary, it has been generally believed to be one of the best in the country.

Even if it should be decided at some time in the future, following the examples presented by the large cities of Europe, to filter the Potomac water, it will be required, in order to save a great part of the cost of the maintenance of the filters to "settle" the water as much as possible before it enters the filters, and the improvement of the receiving reservoir as hereinafter described will still be necessary for the reason that the filtration works, which must be above the heads of the mains that are fed from the lower (the distributing) reservoir, must be at or above the latter reservoir.

Filtration, except by pumping the entire quantity of water consumed and wasted in Washington and Georgetown, being, then, probably out of the question at this time, a comparison of the foregoing tables clearly points out the most important step to be taken for improving the condition of the Potomac water.

It is to provide an additional settling basin, so that when the river is turbid the water can have a longer time for depositing its sedimentary matter before passing into the mains.

This can be done by improving the receiving reservoir.

The receiving reservoir, about 2 miles, following the Conduit road, above the distributing reservoir, has about the same area as the latter, and contains about the same available amount of water.

Its perimeter has a length of about 2 miles. The conduit from Great Falls to the distributing reservoir passes close to a portion of the margin of the receiving reservoir. The part of the conduit that passes around the receiving reservoir is termed the by-conduit. There is an inlet from the conduit to the latter reservoir at its upper end, and an outlet from the reservoir to the conduit at its lower end. They are so

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arranged that the water in its route from Great Falls to the distributing reservoir can be made to pass either directly through the conduit and around the receiving reservoir to the distributing reservoir or through the receiving reservoir, as may be desired.

It was contemplated by General Meigs in his original design for the aqueduct that the water from Great Falls should always pass through the receiving reservoir.

Unlike the distributing reservoir, which has no watershed, the receiving reservoir has an extended watershed of about 4,000 acres. It is mainly to the northward of the reservoir, its northern border crossing the Tennallytown and Rockville road, about 2½ miles above Tennallytown. Its eastern border follows pretty closely the Loughboro and the Tennallytown and Rockville roads, and its general width from east to west is about 2 miles. The greater part of the area of the watershed is very hilly, and nearly the whole of it is devoted to cultivation and grazing. When the reservoir was constructed (nearly forty years ago) there but were but few persons living on its watershed, but now it not only contains Tennallytown, but a large and rapidly increasing population in farmhouses and villas.

The water falling upon this area is carried to the reservoir by several streams, one of which, Little Falls Branch, is of considerable size, and they carry in storms and heavy showers great quantities of detritus, which is rapidly shoaling the reservoir. With the receiving reservoir in its present condition there is no means of excluding the drainage water from the surrounding lands, and, when the Potomac water from Great Falls flows through the reservoir, of preventing the mingling of these two waters.

Every storm and heavy shower brings down to the reservoir through the streams that lead into it and directly from the hillsides not only a great quantity of muddy water which roils the reservoir, but fertilizers and other deleterious substances from the cultivated and grazing lands of its watershed, as well as the drainage and sewerage of Tenallytown and the new village of Chevy Chase. In fact, this reservoir has the usual defects of reservoirs surrounded by and supplied from cultivated and inhabited districts.

The receiving reservoir is admirably suited for settling and storage purposes, if all the water be excluded from it except the water from the Potomac, and the margins be deepened and protected.

These can readily be done if Congress will grant the necessary appropriations.

Capt. Symons, of the Engineers, several years ago made an excellent, and I believe the only practicable, project for the former, and it, and the drawings illustrating it, may be found in the Report of the Chief of Engineers for 1885, pages 2464–2468.

It has been estimated for in the Reports of the Chief of Engineers for 1885, 1890, and 1891.

The project, which is shown on the plat herewith, is to take the waters of East Creek (the stream farthest to the eastward that pollutes the reservoir) and conduct it in an open and paved channel to Mill Creek, together with all the water falling directly into the reservoir from the hills between these two streams; then to take the combined waters of both streams and the water which falls directly into the reservoir from the hillsides between Mill Creek and Little Falls Branch by a proportionally larger channel and a short tunnel to Little Falls Branch. The combined waters of all the streams are then to be taken

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by a still larger channel and another short tunnel to a natural water course below the reservoir.

To catch and throw all the water of the streams into these channels and connecting tunnels, small dams are to be erected across the mouths of the streams below the points where the artificial channels enter and leave their basins, which points are in all cases as close to the reservoir as possible.

The work is planned to give the shortest tunnel lines possible, and both the channels and the tunnels were computed to carry off the greatest known rainfall.

The plan would make this splendid reservoir fully as valuable for settling purposes and as completely shut off from all polluting influences as the distributing reservoir. By it the receiving reservoir would become an additional distributing reservoir, and the time allowed for settling would be considerably more than double the time now allowed. It would give the water from Great Falls, after reaching the "north connection" of the receiving reservoir, a variety of routes for reaching the mains leading to the city, and either could be adopted as the varying conditions of the water might require, as follows: It could be made to pass through the receiving reservoir, thence through the conduit to the distributing reservoir, and through this reservoir, or it could be made to pass around the receiving reservoir, and thence to and through the distributing reservoir, using either reservoir alternately as a settling basin, or, when the water at Great Falls is quite clear, as it is (see the foregoing table) about one-half the time, it could be made to pass from Great Falls directly into the mains without passing through either reservoir.

The estimate of the cost of the foregoing work, including the purchase of the small amount of land required and the cost of completing the fencing of the reservoir lands for the purpose of excluding cattle from these lands, is $129,800, but in order to get the full advantage of this improvement the removal of enough of the deposits from the mouth of Little Falls Branch and the deepening of the reservoir at its head sufficiently to enable us to run the Potomac water freely through the reservoir is indispensable. I judge that an additional amount of about $20,000 will do this, and I therefore recommend that an appropriation of $150,000 be made for the improvement of the receiving reservoir by the works required for cutting off the drainage into it of polluted water and sewerage from the surrounding country; for the purchase or condemnation of the small amount of land required for this purpose, and for the excavation necessary at the head of the reservoir.

The improvement of the receiving reservoir as just indicated is necessary not only for the purpose of excluding all polluted water from the reservoir and reducing the turbidity of the water supply to the city, but for the following additional and important reasons:

(1) *Deficiency in capacity for the storage of unpolluted water.*—By reason of the present condition of the receiving reservoir, the storage capacity of unpolluted water is now limited to the capacity of the lower (the distributing) reservoir, from which are fed all of the mains that supply the city (viz, the 48, 36, 30, and 12 inch mains), or less than four days' supply. The use of the receiving reservoir would double the storage of unpolluted water for the supply of these mains.

(2) *The filling up by silt and destruction of the receiving reservoir now going on.*—Before the erection across the valley of Little Falls Branch of the dam forming the reservoir, the silt brought down by the branch was carried on into the Potomac. Since that time all of this silt has

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been arrested by and deposited in the reservoir, with the result that the upper part of the reservoir has been completely filled up and its capacity for storage has been materially reduced. Unless this process be arrested, it is only a question of time when this reservoir, which probably cost more than $200,000, will be completely destroyed. When the improvement contemplated has been made, not only the polluted water from the surrounding country but all of the silt brought down by Little Falls Branch and the two other streams that empty into the reservoir will be carried off into the Potomac without entering the reservoir.

(3) *The condition of the by-conduit.*—The filling up of the upper part of the reservoir by silt from Little Falls Branch has completely cut off the means of getting Potomac water into it from the "north connection," so that Potomac water can not now be brought into and through the reservoir, which was the purpose for which it was constructed by Gen. Meigs. The supply of Potomac water to the lower (the distributing) reservoir and the city now depends, therefore, on a short piece of conduit about 2,700 feet long, passing around the receiving reservoir, and which is, as before mentioned, termed the by-conduit. This by-conduit was not a part of Gen. Meigs's work, but was constructed (during the late war and while the Washington aqueduct was temporarily under the Department of the Interior) simply as an alternate route for Potomac water at the receiving reservoir. By reason either of defects in the original construction or decay of the mortar since, I find that when the by-conduit is emptied and the water in the reservoir is at its normal height, the water in the latter leaks into the former through innumerable fissures in the arch, and the reverse is doubtless the case when the by-conduit is flowing full and the water in the reservoir is low. I do not think there is any immediate danger that the by-conduit will cave in and thus cut off the entire supply of Potomac water, but its present condition gives a feeling of insecurity which will continue until the works at the receiving reservoir recommended have been completed.

(4) *Deficiency in the capacity of the by-conduit for carrying the full flow of the main conduit.*—As stated elsewhere in this report, I found in removing the accumulation of deposits from the by-conduit that the lining of the tunnel under Dalecarlia Hill, or Tunnel No. 5, which is a part of the by-conduit, is only 8 feet in diameter (a fact not shown in the old reports and maps of the aqueduct), so that the by-conduit can not carry the full flow of the main conduit, which is 9 feet in diameter both above and below the receiving reservoir. For any given head at Great Falls this full flow of the main conduit can only be obtained when the Potomac water can again be carried through this reservoir, and, judging from recent experiences at times of low water in the Potomac, it will be required much sooner than has been anticipated.

Additional project.—In addition to the works required to prevent the flow of polluted waters into the reservoir, the margins of the reservoir should be deepened everywhere to 12 feet, and the side slopes should be protected by walls of dry rubble stone 12 inches thick laid on a lining of broken stone 6 inches thick, precisely as the sides of the lower (the distributing) reservoir are now protected, but this work is not so important for the health of the inhabitants of Washington as the works required to exclude all polluted water and sewerage from the reservoir so that none but Potomac water can pass through it, and it may be postponed if deemed advisable until the latter works be completed. The cost of it, including the cost of removal of the deposits and the

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partial deepening at the head of the reservoir before referred to as indispensable, is estimated at $160,825.50.*, Deducting the $20,200 required for these items, we have for the estimated cost of the improvement of the receiving reservoir by deepening its margins and protecting them by slope walls, $140,625.50.

LOWERING THE HEIGHT OF THE CROSS DAM IN THE DISTRIBUTING RESERVOIR.

The lower reservoir (the distributing reservoir) is divided about half way between the influent and effluent gatehouses by a cross dam, in the middle of the length of which is a narrow cut lined with masonry, through which all the water on its way to the effluent gatehouse, where it enters the mains, must pass.

The draft through this cut is so strong that the major part of the water is drawn straight from the influent gatehouse, which is in a corner of the upper division (the settling division), to the cut, so that when the water is turbid it does not diffuse itself through the whole body of water in this division (110,000,000 gallons) as it should in order that the greatest amount of settling be done.

Neither is the water after it passes through the cut properly distributed through the lower division, which contains about 60,000,000 gallons, for the reason that the draft from the cut to the head of the mains leading to the city from the lower end of the division is so strong that the water all passes in a comparatively narrow stream straight to these mains, so that it also gets very little chance to settle in this division.

Now, as the upper layer of any body of water not quite free of turbidity and in the process of settling is the clearest, if the top of the dam be lowered far enough to allow only a thin sheet (at the present rate of consumption it would be about an inch deep) of water to pass over the dam, as was General Meigs's design, we should have in each division a very effective additional means of clarifying the aqueduct water, and I believe that this improvement in the distributing reservoir being made, and the receiving reservoir being improved as recommended, there would be but rarely, if any, complaint of muddy water.

I estimate the cost of this improvement at the distributing reservoir by lowering the cross dam at $12,500.

PROTECTION OF THE INLET TO THE CONDUIT AT GREAT FALLS.

The bank of the Chesapeake and Ohio Canal, which runs parallel to the Potomac at Great Falls, and about 150 feet from it, is about 16½ feet higher than the uncovered chamber, just above the Maryland end of the aqueduct dam, that forms the inlet from the river to the conduit.

In the flood of November, 1877, which rose at Great Falls to the height of 160 feet above the datum of the aqueduct, or 12 feet higher than the crest of the dam, the canal bank at a point opposite the inlet

* 148,300 cubic yards of excavation, at 35 cents	$51,905.00
16,400 cubic yards of dry stone masonry, at $4.50	73,800.00
8,200 cubic yards of broken stone lining, at $2.50	20,500.00
Total	146,205.00
Add 10 per cent for contingencies	14,620.50
	160,825.50

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was washed down to the river and a part of it into the inlet. I quote from the annual report of the aqueduct for 1878:

> The masonry forming the arch of the feeder was uncovered from a point near the middle of the canal to the mouth of the feeder, a distance of 150 feet. The chamber at the head of the aqueduct was filled with stones that had formed the slope wall of the canal, and the aqueduct feeder for a distance of 300 feet was filled with débris to depths varying from 3 to 6 feet, so as to entirely stop the flow of water during the ordinary low stages of the river.

In the still higher flood of June, 1889, which rose to the height of 16 feet over the aqueduct dam, the canal bank was again washed down to the river, but fortunately the damage did not occur immediately opposite the inlet to the conduit, but from 200 to 400 feet higher up, so that the major part of the débris being left on the margin of the river and a part of it being carried over the dam, not so much filling of the inlet to the conduit was done, but, as in the flood of 1877, it was partially obstructed.

The annual report of the aqueduct for 1889 says:

> The banks of the Chesapeake and Ohio Canal above and below the mouth of the conduit were carried away and that opposite the conduit was threatened. A number of men were kept at work on this bank during the freshet, and it is believed that had it not been for the energetic work of this force and the widening and strengthening of the bank at this locality in April, great damages would have occurred at the mouth of the conduit.

It will be observed that in the freshet of 1877 not only the inlet chamber, but the conduit itself was filled to a depth of from 3 to 6 feet *for a distance of 300 feet in from its mouth*, but the water in the river being at a high stage, there was still waterway enough in the conduit above the débris to enable the supply to the city to be kept up. Had a complete closure of the mouth of the conduit occurred, with 12 to 16 feet of water over it, there would have been no possible way, with the torrent raging over the mouth, to remove the obstruction before the river subsided, and the water supply to the city would have been cut off.

There is no more important part of our system of water supply to be carefully guarded than the head of the conduit at Great Falls, and in order to avert dangers like those of 1877 and 1889, to which the water supply is liable in every freshet, a masonry wall should be built between the river and the canal bank, rising a few feet higher than the latter, and extending up river from the mouth of the conduit as far as the limit of the Government land, and thence at about a right angle and still on the Government land to the shore of the river. I estimate the cost of this wall at $5,000.

EXTENSION OF OUTLET OF WASTE WEIR NO. 3.

In order to provide means for emptying the conduit in case of a break in it, or for any purpose of repair, and to regulate the quantity of water passing down the conduit, three waste weirs or openings from the conduit are provided in its 11½ miles of length. One of the most important of them is waste weir No. 3, which is between the receiving reservoir and the distributing reservoir, and about half a mile above the latter. One of its most important functions is to enable us to control the height of water in the distributing reservoir, so that, on the one hand, it shall not fall below the height required to give the best possible supply to the city, and, on the other, it shall not rise so high as to endanger the dams of the reservoir. This is ordinarily done by telephonic orders to the watchman gate-keeper at Great Falls, who is in

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charge of the gates at the head of the conduit, but in case of a break in the telephone line, and communication with him, except by mail, being cut off, reliance must be had on the waste weirs, and especially on No. 3, which is in charge of the watchman gate-keeper at the distributing reservoir. The overflow from this waste weir is, for the distance of about 270 feet, in a deep gully through private property to a natural water course, and thence under the Chesapeake and Ohio Canal to the Potomac. Property in this vicinity is getting to be valuable, streets are being laid out through it, and the outflow from the waste weir is liable to be obstructed by the filling of the gully by the owners of the land. The difficulty can be obviated by laying a 36-inch cast iron pipe in the gully from the waste weir to the natural water course, at an estimated expense of $2,500.

STORAGE YARDS.

I have provided supplies for use in case of breaks in the 48-inch and other mains, comprising sections of pipe, curves, crosses, reducers, sleeves, etc., a heavy wagon for hauling them where needed, lifting jacks, and efficient pumps; also machinery for lowering the pipes in the trenches, and the implements and material required for handling and calking.

A portion of these supplies has been placed in a yard which I have arranged on the public land at the distributing reservoir, for use in the country portions of the routes of the mains, and the remainder for use in the city portions of these routes has been placed in a portion of Twenty-seventh street, near M Street Bridge, which has been loaned for the purpose by the District government until the street is wanted for improvement.

As we shall not be able, probably, to retain this place, except for a short time, a permanent yard in the city should be purchased for use as a storage yard. It should be near this office and at or near the grade of the street, so that the heavy castings and machinery required for repairs can be quickly gotten out.

I believe that a suitable lot can be obtained by purchase, or if need be by condemnation, for $10,000, and I recommend an appropriation of this amount for the purpose.

CLEANING THE BOTTOM OF THE DISTRIBUTING RESERVOIR.

The sedimentary deposits of about twenty years, within which time the distributing reservoir has not been cleaned out, have raised the bottom of its upper division (the settling division) about 9 inches and of the lower division about 4 inches.

These deposits have diminished the capacity of the reservoir about 8,000,000 gallons, and, although it is probable that these deposits, which are mostly clay, are not deleterious to the water, they should be removed as soon as an appropriation can be obtained for the purpose. It would require the removal of about 39,500 cubic yards, the estimated cost of which, at 35 cents per cubic yard, is $13,825.

WIDENING AND DEEPENING THE SPILLWAY AT THE RECEIVING RESERVOIR.

The overflow weir at the head of the spillway was constructed in 1885. It is 75 feet long, 27½ feet wide, with side walls 3 feet above the

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flow line of the reservoir. It is immediately over the by-conduit, and is paved with stone. The channel of the spillway below this weir has never been completed, and the waterway is not sufficiently large to carry off the overflow from the reservoir fast enough to keep it below the top of the side walls in exceptionally heavy storms. In such cases the earth covering of the conduit at the ends of the overflow weir is liable to be washed away and the by-conduit endangered. I estimate that the work will cost $2,000.

REPAVING BRIDGE NO. 3 (GRIFFITH PARK BRIDGE) AND BRIDGE NO. 4 (CABIN JOHN BRIDGE).

The floors of these bridges were paved several years ago with asphalt, which is almost completely worn out. For the safety of the conduit, which is carried across these bridges beneath their floors, they should be repaved, and, as the travel over them is very great and is confined to a width of only 16 feet, it is very destructive to the floors. I therefore propose to repave them with granite blocks. This work will cost about $5,000.

STOREHOUSE AT GREAT FALLS.

There is no place for storage of the public property at Great Falls or for cement and other materials required when any work of construction or repairs is going on on that division of the aqueduct. A storehouse is urgently needed, and I propose to erect one about 40 by 20 feet in size, at a cost of about $1,500. The Chesapeake and Ohio Canal is now in operation, and the stone for the walls can be cheaply obtained from the Government quarry at Seneca, a short distance above the falls.

PROTECTION OF THE CONDUIT AT WASTEWEIR NO. 1.

The masonry at Wasteweir No. 1, which is at the mouth of a tunnel outlet from the side of Tunnel No. 1, near Great Falls, has never been completed, and by reason of this the head of water in the conduit can not always be maintained as high as is necessary. The mouth of this tunnel outlet needs also a protection in the form of a heavy iron grating against the indraft of logs and other driftwood into the conduit in freshets, which endangers the conduit and the supply of water to the city. In my inspection last year of the interior of the conduit between Great Falls and the distributing reservoir there was found in the conduit, below Wasteweir No. 1, a telegraph pole which must have been drawn into Tunnel No. 1 through the side tunnel referred to during the great flood of 1889, when the river rose 75 feet at this place and overflowed the mouth of the outlet tunnel. The cost of this work will be about $5,000.

INSERTING AIR VALVES AND BLOW-OFF VALVES IN THE 30-INCH AND 36-INCH MAINS.

In respect of this estimate I beg leave to quote from my annual re-report of 1890, as follows:

It is important that more efficient facilities be provided for emptying and filling the old mains in case of accident and of making connections from main to main.

In either case a section of the main must be cut out and a new piece inserted, but before this can be done the main valve at whatever distance on either side must be shut, and the section of the main between these two valves, generally more than a

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mile long, must be emptied of its water. The time required for emptying depends not only on the the sizes of the blow-offs in the valleys crossed by the mains, but also on the sizes of the air valves provided at the summits, for the water can not, of course, in any case be gotten out of a main any faster than the air required to take its place can be gotten in.

In making the connections at New Jersey avenue and L street between the 36-inch main and the 24-inch by-pass, on the night of the 14th of April last, more than five hours were consumed in freeing the main of water, owing to insufficient blow-offs and air valves in the 36-inch main, and the refilling of the main after the connection had been made was so much prolonged by the want of proper valves for the egress of the air that it was nearly noon of the next day before the charging of the main was completed.

Similar delays occurred at each of the numerous connections between the mains that were made after the 48-inch main was completed, and I was in each case obliged in getting the air into the mains for emptying and out of them for filling them again with water, to have recourse not only to fire hydrants, but to the service-pipe spigots in the houses in the vicinities of these connections.

These delays are very expensive, night work costing about double the rates of day work, and the danger in case of fire in the district cut off from its supply of water is so great that large air valves and blow-off valves should be placed on both the 30 and 36 inch mains as soon as an appropriation can be obtained for the purpose. A patented device of which I have obtained the details since the date of the report referred to very much reduces the time required for inserting these valves, as well as their cost, and what is very important, it enables the work to be done while the mains are under their ordinary pressure. The cost of inserting the required blow-off and air valves in the 36 and 30 inch mains will be about $6,250.

REMOVAL OF THE ACCUMULATION OF DEPOSITS FROM THE CONDUIT.

As stated elsewhere in this report, my inspection of the interior of the conduit of September 1, 1891, showed a great accumulation of sedimentary deposit in the conduit throughout its entire length between Great Falls and the distributing reservoir, and these deposits should be removed as soon as money can be obtained for the purpose. For the reason that the supply of water to the city must not be interrupted, a large part of the work must be done at night. It will therefore be a tedious and expensive operation, and it can not be accomplished by means of the small annual appropriations for maintenance and repair, except it be done little by little each year, and then only by omitting other necessary work. I include an item of $14,000 for the removal of the deposits in the conduit, and this, if granted, would enable the entire conduit to be thoroughly cleaned out in one year.

REBUILDING THE BRIDGE OVER THE SPILLWAY AT THE RECEIVING RESERVOIR.

The Conduit Road Bridge over the spillway at the receiving reservoir and just beyond the District line, is a wooden bridge on trestles which was built many years ago, and is much decayed. The travel over the bridge is very heavy, and in order to prevent accidents, frequent repairs are necessary.

It should be replaced by a masonry bridge, and I include an estimate of $18,000 for it in my annual estimates.

DEEPENING THE DISTRIBUTING RESERVOIR.

The present bottom of the distributing reservoir being at reference 135 above the aqueduct datum, and the flow line of the reservoir being

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at reference 146 above this datum, the available depth of water is 11 feet.

It has often been recommended in former annual reports that the depth be increased 13 feet, or to reference 122, the depth of the axes of the four 48-inch connections between the screen house and the gate chamber.

This would increase the storage capacity of the reservoir from about 170,000,000 gallons to about 290,000,000, gallons, and add to the coolness of the water and also to its purity, for, unlike the receiving reservoir, which is nearly surrounded by woods, the distributing reservoir is fully exposed to winds, and the waves are sometimes so great as to disturb the bottom and make the water roily.

Should this be done bermes of 10 feet in width should be left at the foot of the present slope walls protecting the sides of the reservoir, the tops of these bermes should be paved, and the deepened portions of the sides should be protected by slope walls of dry-rubble masonry 12 inches thick, laid on a broken-stone lining 6 inches thick.

I estimate the cost of the work at $290,000 in round numbers, as follows:

580,000 cubic yards of excavation, at 35 cents	$203,000
10,500 cubic yards of rubble-slope wall, at $4.50	47,250
5,300 cubic yards of broken-stone lining, at $2.50	13,250
Total	263,500
Add 10 per cent for contingencies	26,350
	289,850

I consider the work of deepening this reservoir to be of very great importance for the reasons given, and it should be done as soon as appropriations can be obtained for it, but as the improvement of the quality of the aqueduct water, the increase of storage capacity above the heads of our mains, the protection of the aqueduct, and other works herein mentioned are of more importance at this time, I have not included it in the estimates for the next fiscal year.*

RAISING THE HEIGHT OF THE DAM AT GREAT FALLS.

I found during the very low stage of the Potomac last summer that the height of the dam at Great Falls is not sufficient at the lowest stages of the river to keep the conduit full at its head, or to enable it to deliver as much water as is now consumed and wasted in the city, and at the same time keep up the head in the mains at the distributing reservoir to 146 feet above datum, which is necessary for the supply by gravity of the high northern portions of the city and of Capitol Hill. The only remedy for this deficiency, if it should continue, and it is one that should be made before any further steps are taken for increasing the supply from the distributing reservoir by the tunnel to the new reservoir near Howard University, or by a new main leading directly to the city, neither of which is now necessary by reason of the laying

*The late Gen. Meigs, in one of his frequent notes respecting the aqueduct, in which, up to his death on the 2d of January last, he continued to retain the deepest interest, called my attention to the care that would be required whenever the distributing reservoir is deepened, not to cause leaks by uncovering and cutting into the uptilted and more or less dislocated gneiss formation that he found to underlie some portions of the reservoir.

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of the 48-inch main, is the raising the height of the dam. The following is an estimate of the cost of the work:

2,134 cubic yards of stone masonry, at $35	$74,690
3,333 cubic yards of riprap, at $2	6,666
Damages on account of flooding of land and other damages	12,000
Total	93,356
Add 10 per cent for contingencies	9,335
	102,691

This is a work that will doubtless soon have to be done, but there are so many things that are immediately necessary, I do not include an estimate for it in the estimates for the next fiscal year.*

DESIRED PROVISION IN RESPECT OF APPROPRIATIONS FOR THE AQUEDUCT.

Appropriations for the aqueduct are now fiscal year appropriations, and their availability terminates on the 30th of June of each year. Whenever appropriations are delayed there is liable to be a time in the early part of every other fiscal year during which, should a break occur in a main either in the city or in the country this side of the distributing reservoir or in the conduit, or should any disaster occur at the reservoirs or at Great Falls there is no money available for repairs.

If the appropriations for the aqueduct should be made available until expended some of the less urgent repairs toward the end of the year could be postponed until the next appropriation should become available, so that there would always be money in hand for repairing breaks in the mains or other works of repair.

A leak in one of the city's old and decayed street mains or in one of the hundreds of small service pipes that cross the route of the 48-inch main, for instance, by undermining it may cause it to break and the quantity of water that would be discharged on the street, especially in the low levels of the route, would be so enormous that the property and even the lives of citizens in the vicinity of the break might be endangered.†

And in case of appropriations for specific works like those I have recommended it is sometimes not advantageous, either in respect of economy or the quality of the work, to oblige the work to be fully completed at the end of the fiscal year.

Sometimes, by reason of the late date at which appropriations become available, or of the weather, or of the condition of the river, the work can not be fully completed within this time without hurrying it

* The increase of height for which this estimate is made is 2.5 feet, which would raise the dam to reference (150.5). This would be required in order to enable the river when at its summer flow of, say, 6 inches over the dam to completely fill the conduit at its head. I find among the interesting and instructive notes that I received from the late Gen. Meigs and have carefully filed for the information of the officers in charge of the aqueduct, one dated March 1, 1891, of which the following is an extract: "The original design was to set the lip of the dam at the Great Falls at the height of 150 feet above tide, for which height all the profiles and wasteweirs were built. The back filling over the conduit would now allow a height of water some 2 feet higher than the dam to flow safely through the conduit, and, if needed, another foot or two and corresponding widening of the embankments would fit the aqueduct to convey, with increased height of dam lip, a very much increased flow of water to the city."

† The internal pressure on our mains at some portions of their routes is about 43 pounds to the square inch. This great pressure will be better appreciated if it be stated that it is nearly 40 tons to the running foot of 48-inch main.

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so much as to be detrimental to the interests of the Government. I do not know of any appropriations that more require to be made available until expended, like appropriations for river and harbor improvements, than appropriations for the Washington Aqueduct.* I urgently recommend, therefore, that it be done, and that the following clause be attached to the next appropriations for the aqueduct and be made to operate on all future appropriations for it.

Provided, That the appropriations for the Washington Aqueduct for the fiscal year ending June 30, 1894, and thereafter until otherwise provided by law, shall not be considered as fiscal-year appropriations.

DESIRED INCREASE IN THE ANNUAL APPROPRIATION FOR MAINTENANCE, PRESERVATION, AND REPAIR OF THE AQUEDUCT, AND THE RESERVOIRS, MAINS, ROADS, ETC., CONNECTED THEREWITH.

While works that have cost $565,000 have recently been added to the aqueduct system by the laying of more than 8 miles of 48-inch and other large water mains under the act of March 2, 1889, with their numerous valve chambers, main valves, air valves, blow-off valves, and other adjuncts, all of which have to be carefully watched and kept in repair, there has been no increase in the appropriation for maintenance and repair of the aqueduct.

It has been for many years and is now $20,000, and it proves entirely inadequate for keeping in repair the long line of works, including the dam at Great Falls, the conduit, the Conduit road (which is paved for the protection of the conduit), the reservoirs, the gatehouses, the fences of the aqueduct and Conduit road lands, the dwellings of the watchmen of the different divisions, and the more than 20 miles of trunk mains in the city supplying the distributing system of the District of Columbia, besides paying the salaries of the watchmen and other employés.

Twenty-one thousand dollars was asked for in my last annual estimates, and it is again asked for. It is not a large sum to provide for the annual maintenance and repairs of works that have cost more than $4,000,000, and I could expend much more in works of preservation and repair that would be for the best interests of the Government.

The height of water on the dam at Great Falls varied during the year from a minimum of 0.6 foot on September 26, 27, 28, 29, 30, October 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 19, and 20, 1891, to a maximum of 3.5 feet on January 16, and March 10, 1892.

Superintendent R. C. Smead, Chief Clerk Simon Newton, Valve-tender and Machinist Thomas Ferguson, and the other employés of the

* Even when, in the cases of delay in the passage of the regular appropriation bills, temporary provisions are made for the expenditures of the Government, considerable lengths of time after the beginning of the fiscal year elapse before official information (which only would warrant expenditures under these provisions of law) reaches disbursing officers.

On this 8th of July, 1892, in blowing off the 30-inch main at Foundry Branch, the heavy bronze sleeve through which the valve stem works was badly fractured, so that the valve can not be moved until a new sleeve be cast and turned at some foundry. The regular appropriation bill has not yet been passed by Congress. I have only information from newspapers that any temporary provisions have been made for the expenditures of the Government and I have no money to my credit for the repair of the valve.

Fortunately the valve happened to be shut at the instant when the accident occurred, and is now shut, else it would have wasted into the Potomac the water in the distributing reservoir at the rate of about 2,000,000 gallons per hour at a time when, on account of the low stage of water in the river, we have none whatever to spare.

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aqueduct have been faithful in the performance of their responsible duties. Mr. Thomas Sullivan, Mr. John Halloran, and Mr. Daniel Harrington, for many years watchmen gate-keepers at Great Falls and at the receiving and distributing reservoirs, in addition to their other duties, have skillfully and energetically acted as foremen of laborers engaged on the works of repair.

Money statement.

July 1, 1891, balance unexpended	$23, 944. 25
June 30, 1892, amount expended during fiscal year	21, 705. 74
July 1, 1892, balance unexpended	2, 238. 51
July 1, 1892, outstanding liabilities	2, 238. 51

ESTIMATES.

The estimates of appropriations that should be made for the year ending June 30, 1894, are as follows, and I urgently recommend that the provision of law suggested in this report be attached to the next appropriations, for the reasons stated:

For improving the receiving reservoir by the works required for cutting off the drainage into it of polluted water and sewerage from the surrounding country; for the purchase or condemnation of the small amount of land required for the purpose, and for the excavation necessary at the head of the reservoir	$150, 000
For improving the receiving reservoir by deepening its margins and protecting them by slope walls	140, 625
For lowering the height of the cross dam at the distributing reservoir	12, 500
For protecting the inlet to the aqueduct at Great Falls	5, 000
For extending the outlet of Wasteweir No. 3	2, 500
For purchase or condemnation of a site for a storage yard	10, 000
For cleaning out the distributing reservoir	13, 825
For widening and deepening the spillway at the receiving reservoir	2, 000
For repaving Griffith Park and Cabin John bridges	5, 000
For storehouse at Great Falls	1, 500
For protecting the conduit at Wasteweir No. 1, near Great Falls	5, 000
For inserting air valves and blow-off valves in the 36-inch and 30-inch mains	6, 250
For removing the accumulation of deposits in the conduit	14, 000
For rebuilding the bridge over the spillway at the receiving reservoir	18, 000
For maintenance and repairs of the aqueduct, and the reservoirs, mains, roads, etc., connected therewith	21, 000

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Condition of water at Great Falls, receiving reservoir, and distributing reservoir, and height of water over dam at Great Falls, for each day in the year.

Day of month.	Condition of water.			Height of water over dam at Great Falls, feet.	Condition of water.			Height of water over dam at Great Falls, feet.	Condition of water.			Height of water over dam at Great Falls, feet.	Condition of water.			Height of water over dam at Great Falls, feet.
	Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, effluent gate house.		Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, effluent gate house.		Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, effluent gate house.		Great Falls.	Receiving reservoir, south connection.	Distributing reservoir, effluent gate house.	
	July, 1891.				August, 1891.				September, 1891.				October, 1891.			
1	18	36	9	1.00	3	24	9	1.10	6	33	12	(*)	36	36	36	.60
2	4	36	10	1.20	5	16	8	1.00	9	36	14	.90	36	36	36	.60
3	4	33	12	1.50	8	30	9	1.00	17	36	11	.90	36	36	36	.60
4	4	25	10	1.60	9	32	10	1.00	24	36	12	.80	36	36	36	.60
5	6	29	9	1.30	18	36	13	1.00	2	36	15	1.10	36	36	36	.60
6	20	29	11	1.10	4	36	20	1.50	1	4	12	1.40	36	36	36	.60
7	16	34	19	1.00	2	36	24	1.10	2	3	6	1.10	36	36	36	.60
8	12	36	23	1.00	2	36	32	1.00	4	3	4	1.20	36	36	36	.60
9	3	31	24	1.40	4	36	7	1.00	8	3	4	1.30	36	36	36	.60
10	4	29	20	1.40	14	36	7	1.00	15	2	6	1.10	36	20	36	.60
11	7	33	22	1.60	29	36	16	.90	15	2	7	1.00	36	22	36	.70
12	10	35	23	1.40	32	36	20	.90	18	2	11	1.00	36	18	36	.70
13	24	36	30	1.20	34	36	29	.80	18	3	13	1.00	36	15	36	.70
14	26	36	36	1.10	36	36	36	.80	28	3	14	.80	36	19	36	.80
15	28	36	36	1.10	30	36	36	.80	31	4	17	.80	36	21	36	.70
16	4	36	36	1.10	36	36	36	.70	36	5	24	.80	36	26	36	.70
17	4	36	29	1.10	25	36	36	.70	36	6	29	.80	36	23	36	.70
18	1	36	15	1.10	36	36	36	.70	36	10	36	.70	36	25	36	.70
19	2	17	9	1.20	36	36	36	.70	36	13	36	.70	36	26	36	.60
20	1	30	6	1.40	36	36	36	.70	36	19	36	.70	36	31	36	.60
21	1	24	4	1.40	36	36	36	.70	36	27	36	.70	36	27	36	.70
22	2	36	3	1.40	20	36	36	.80	36	36	36	.70	36	20	36	.70
23	3	36	4	1.20	8	36	36	.80	36	36	36	.70	36	28	36	.80
24	8	3[illegible]	4	1.30	18	34	36	.70	36	36	36	.70	36	26	36	.80
25	4	30	4	1.30	4	36	36	.90	36	36	36	.70	36	28	36	.80
26	4	34	4	1.30	4	36	36	1.10	36	36	36	.60	36	34	36	.80
27	1	31	5	1.20	6	36	25	1.10	36	36	36	.60	36	36	36	.80
28	4	32	7	1.10	8	36	16	1.10	36	36	36	.60	36	36	36	.80
29	4	30	8	1.10	6	36	11	1.60	36	36	36	.60	36	36	36	.70
30	7	34	7	1.00	6	26	9	1.40	36	36	36	.60	36	36	36	.70
31	3	28	7	1.10	4	26	11	1.20	36	......	......	......	36	36	36	.70

Day of month.	November, 1891.				December, 1891.				January, 1892.				February, 1892.			
1	36	36	36	.70	8	30	4	.90	4	8	4	1.20	20	18	36	1.20
2	36	36	36	.70	8	26	6	.80	4	8	4	1.20	30	16	36	1.20
3	36	36	36	.70	12	26	7	.80	4	12	3	1.20	19	16	36	1.20
4	36	36	36	.70	16	25	8	(*)	2	9	4	1.40	26	18	36	1.10
5	36	36	36	.70	5	29	9	(*)	2	11	5	1.30	27	18	36	1.10
6	36	36	36	.70	1	10	10	(*)	4	10	4	1.30	30	18	36	1.10
7	36	36	36	.70	1	7	6	2.20	7	10	3	1.20	23	19	36	1.00
8	36	36	36	.70	1	7	3	1.70	8	12	4	1.20	12	24	36	1.10
9	36	36	36	.70	2	5	2	1.50	9	13	4	1.10	4	32	36	1.20
10	36	36	36	.70	3	6	2	1.30	11	12	5	1.00	6	14	36	1.30
11	36	36	36	.70	4	6	2	1.30	14	16	6	.90	8	9	27	1.60
12	36	36	36	.70	6	6	3	1.10	20	24	9	.90	7	13	21	1.60
13	36	36	36	.90	7	6	3	1.10	3	23	15	1.20	10	12	17	1.20
14	26	36	36	.90	17	9	3	1.00	2	20	12	1.80	10	12	17	1.20
15	20	36	36	.90	20	11	4	1.00	1	15	9	3.30	12	13	17	1.20
16	22	36	36	.90	18	11	4	.90	1	10	7	3.50	12	14	18	1.20
17	15	36	36	.90	9	10	6	.90	2	8	5	2.80	16	18	18	1.20
18	7	36	36	.90	20	12	7	.80	2	5	4	2.10	29	22	20	1.10
19	6	36	36	.90	25	19	9	.90	2	5	3	2.00	32	26	23	1.10
20	10	36	36	.90	31	20	15	.90	3	5	2	2.40	32	17	26	1.10
21	20	36	30	.90	33	21	20	.80	5	6	3	2.10	36	20	20	1.10
22	31	36	24	.90	33	22	23	.80	4	9	4	1.90	36	21	22	1.10
23	29	36	25	.90	33	17	26	.80	12	10	4	1.90	36	17	32	(*)
24	7	36	30	(*)	31	16	30	.80	10	10	6	1.60	36	12	36	(*)
25	8	36	36	(*)	3	8	36	.80	13	10	10	1.60	36	12	26	1.10
26	6	36	36	1.00	4	5	18	1.10	10	12	10	1.60	36	12	26	1.10
27	6	36	36	1.00	4	5	8	1.20	10	10	11	1.30	36	15	30	1.10
28	3	36	23	1.00	3	4	5	1.40	10	7	13	1.20	36	21	36	1.10
29	3	36	12	1.00	3	6	4	1.30	21	8	22	1.20	36	30	36	1.10
30	6	32	5	.90	5	5	3	1.30	19	8	36	1.20	36	......	......	......
31	......	......	......	......	5	7	3	1.20	24	10	36	1.20	36	......	......	......

* Water shut off from conduit and the gauge could not be read on these days.

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Condition of water at Great Falls, receiving reservoir, and distributing reservoir, and height of water over dam at Great Falls, for each day in the year—Continued.

Day of month.	March, 1892. Condition of water. Great Falls.	March, 1892. Condition of water. Receiving reservoir, south connection.	March, 1892. Condition of water. Distributing reservoir, effluent gate house.	March, 1892. Height of water over dam at Great Falls, feet.	April, 1892. Condition of water. Great Falls.	April, 1892. Condition of water. Receiving reservoir, south connection.	April, 1892. Condition of water. Distributing reservoir, effluent gate house.	April, 1892. Height of water over dam at Great Falls, feet.	May, 1892. Condition of water. Great Falls.	May, 1892. Condition of water. Receiving reservoir, south connection.	May, 1892. Condition of water. Distributing reservoir, effluent gate house.	May, 1892. Height of water over dam at Great Falls, feet.	June, 1892. Condition of water. Great Falls.	June, 1892. Condition of water. Receiving reservoir, south connection.	June, 1892. Condition of water. Distributing reservoir, effluent gate house.	June, 1892. Height of water over dam at Great Falls, feet.
1	2	12	30	1.80	4	8	6	2.10	35	25	19	1.50	26	4	14	1.20
2	2	4	10	1.70	7	9	7	2.00	36	26	23	1.40	5	4	23	1.30
3	4	4	3	1.40	10	8	8	1.90	36	26	30	1.30	21	5	36	1.20
4	5	4	3	1.30	17	11	9	1.80	36	26	36	1.30	25	8	36	1.20
5	6	5	3	1.30	17	12	12	1.70	36	28	36	1.30	27	11	26	1.20
6	6	5	4	1.40	10	14	18	1.70	36	33	36	1.20	15	8	36	(*)
7	4	5	5	2.20	14	16	20	1.70	36	36	36	1.20	2	9	36	(*)
8	4	5	5	2.30	17	15	24	1.70	36	36	36	1.20	3	8	13	(*)
9	3	4	6	2.80	18	17	27	1.70	36	36	36	1.10	5	5	12	1.20
10	1	7	5	3.50	12	18	23	1.60	36	36	36	1.10	2	4	12	1.70
11	2	4	3	3.20	20	22	23	1.50	36	36	36	(*)	2	4	8	2.00
12	2	4	3	2.50	31	22	25	1.40	15	36	36	(*)	2	4	8	1.70
13	4	5	5	2.10	33	28	36	1.30	36	36	36	(*)	3	6	5	1.60
14	6	5	5	1.90	36	31	36	1.30	36	36	36	1.00	3	5	4	(*)
15	8	8	5	1.80	36	31	36	1.30	36	36	36	1.10	5	6	6	(*)
16	13	8	7	1.70	36	30	36	1.30	1	36	36	1.10	8	8	7	1.10
17	25	18	8	1.60	36	36	36	1.30	2	30	17	1.10	9	14	5	1.10
18	27	12	9	1.50	28	31	36	1.40	21	20	15	1.00	17	14	11	1.00
19	32	13	11	1.40	8	32	36	(*)	33	36	14	1.00	15	14	17	1.00
20	22	12	14	1.40	21	31	36	(*)	26	36	19	1.10	15	18	24	1.10
21	30	12	18	1.40	10	31	36	2.00	26	36	26	1.20	1	25	27	1.30
22	32	12	26	1.30	8	15	36	2.00	3	36	36	1.40	1	25	14	1.50
23	31	13	36	1.30	5	25	25	2.30	3	36	36	1.50	3	34	11	1.30
24	4	15	36	1.70	3	11	19	3.10	4	36	36	1.50	4	34	9	1.20
25	4	5	27	1.90	2	7	14	2.80	6	36	30	(*)	4	22	9	1.10
26	3	7	11	2.40	3	6	11	2.30	13	36	30	(*)	4	36	8	1.00
27	4	9	9	2.20	12	7	14	2.00	1	3	15	(*)	6	36	8	.90
28	2	4	9	2.50	18	10	15	1.70	4	2	9	1.20	1	36	8	1.00
29	2	4	6	2.80	20	15	17	1.70	13	2	5	1.20	4	36	8	1.00
30	4	4	5	2.50	28	16	17	1.50	16	3	8	1.20	3	36	7	1.00
31	4	7	5	2.20	......	......	......	......	22	3	9	1.20	......	......	......	......

* Water shut off from conduit and the gauge could not be read on these days.

Number of days during the fiscal year 1891–'92, on which the water was clear or turbid at the places indicated.

Place.	Clear.	Slightly turbid.	Turbid.	Very turbid.
Great Falls	140	41	46	139
Receiving reservoir	191	41	67	67
Distributing reservoir	178	34	70	84

NOTE.—In determining the condition of the water a metallic tube with glass ends is used. This is filled with water, and the distance at which a ball immersed in the water can be seen from one of the ends is noted. When it can be seen at a distance of from 22 to 36 inches, inclusive, it is considered clear; from 15 to 21 inches, slightly turbid; from 8 to 14 inches, turbid, and from 0 to 7 inches, very turbid.

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Table showing daily gauge pressures at the office of the Washington Aqueduct at 9 o'clock a. m.

Month.	Main.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Average.
1891.	*Inch.*																																
July	30	35	36	36	36	34	36	36	36	36	36	36	36	35	35	35	36	36	35	36	35	35	35	35	35	35	36	35	35	35	35	35	35.42
	36	35	36	36	36	36	36	36	36	36	36	36	36	35	35	35	36	36	35	36	35	35	35	35	35	35	36	35	35	35	35	35	35.48
	48	38	38	38	39	38	37	37	36	38	38	38	38	38	37	38	38	38	36	39	38	38	38	38	38	38	39	38	38	38	38	38	37.87
August	30	34	36	35	35	35	35	35	35	36	36	34	34	35	35	34	36	35	35	34	34	34	34	34	34	35	34	34	34	34	34	34	34.61
	36	34	36	35	35	35	35	35	35	36	36	34	34	35	35	35	36	35	35	34	34	35	35	35	34	35	35	35	35	35	35	35	34.93
	48	36	38	38	38	38	38	38	38	39	34	39	37	38	37	38	38	38	38	38	38	39	38	38	38	39	38	38	38	38	39	39	37.93
September	30	34	34	34	34	34	36	35	35	35	35	35	35	36	36	36	35	34	32	33	34	34	34	34	34	34	34	34	32	31	35	....	34.36
	36	34	32	32	32	34	36	35	35	35	35	35	35	36	36	36	35	34	32	33	34	34	34	34	34	34	34	34	34	34	35	....	34.23
	48	38	37	37	37	37	39	39	38	38	38	38	38	38	38	38	39	37	37	37	37	37	37	37	37	37	37	37	37	37	38	....	37.53
October	30	34	34	34	34	34	35	34	34	34	34	36	35	34	35	36	35	34	36	34	35	34	35	36	35	36	34	34	35	35	35	35	34.68
	36	34	34	34	34	34	35	34	34	34	34	36	35	34	35	36	35	34	36	34	35	34	35	36	35	36	34	34	34	34	35	36	34.64
	48	38	38	38	38	37	38	38	38	38	38	38	38	38	37	37	37	37	38	37	38	37	38	37	37	38	37	37	37	37	37	37	37.51
November	30	35	34	34	36	34	36	35	36	36	35	36	36	35	35	36	36	36	35	35	35	35	36	36	36	35	35	34	35	35	35	....	35.27
	36	35	36	36	36	36	35	35	36	36	35	36	36	35	35	36	36	36	35	35	35	35	36	36	36	35	35	35	35	35	34	....	35.43
	48	37	37	37	37	38	37	37	38	38	38	38	37	38	38	39	38	38	37	37	37	37	38	38	37	37	37	37	37	38	37	....	37.47
December	30	35	35	35	35	35	35	35	35	35	34	34	36	36	36	36	37	36	35	35	36	36	37	36	37	37	36	36	35	37	36	36	35.64
	36	34	34	35	35	35	36	35	35	35	35	35	37	37	35	36	36	36	36	35	36	36	37	36	37	37	36	36	35	37	36	36	35.71
	48	37	37	37	37	37	37	36	37	37	37	38	38	38	37	38	38	37	38	37	37	37	37	37	38	37	37	37	38	38	38	38	37.32
1892.																																	
January	30	36	37	37	35	35	36	35	35	36	35	34	36	36	37	37	36	36	37	37	37	36	35	36	36	36	36	35	35	36	36	36	35.90
	36	36	37	37	35	36	36	35	35	36	35	34	36	36	37	38	37	36	37	37	37	36	35	36	36	36	36	35	35	36	36	36	36.00
	48	38	38	38	37	37	37	37	37	37	37	37	37	37	37	37	38	38	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37.16
February	30	36	36	37	36	36	33	35	37	36	36	36	36	35	35	35	36	35	35	36	36	36	36	35	35	35	36	36	36	35	....	....	35.62
	36	36	36	37	36	36	36	37	37	37	37	37	37	36	36	36	36	35	35	36	36	36	36	35	35	35	36	36	36	35	....	....	36.03
	48	37	37	37	37	37	37	38	38	38	38	38	38	37	37	37	38	37	38	38	38	38	38	36	36	37	36	36	37	37	....	....	37.27
March	30	35	35	35	37	37	35	36	37	36	36	34	35	36	35	35	35	35	35	35	36	35	35	36	37	36	38	36	36	37	36	37	35.77
	36	35	35	35	36	37	35	36	37	36	36	35	35	36	35	36	35	35	35	35	36	35	36	37	37	37	38	37	36	37	36	37	35.93
	48	37	37	37	37	37½	37½	37	37½	37	37	37	37	37	37½	37	37½	37½	37	37½	37	37	37½	37½	37½	37	37½	38	38	37½	37½	37	37.27
April	30	37	37	37	36	36	37	35	36	35	36	35	34	36	36	36	36	36	37	36	35	35	36	36	36	35	35	34	34	36	34	....	35.66
	36	37	37	36	36	36	36	36	36	35	37	35	34	36	36	36	36	36	37	36	35	35	36	36	36	36	35	35	35	36	34	....	35.76
	48	37½	37½	37½	37	37	37	37½	37½	37	38	37½	37½	37½	37	37½	36	36	37½	37	36	37	37	37	37	37	37½	37½	37½	37	37	....	37.16
May	30	34	36	35	36	34	33	34	34	34	33	33	33	32	33	33	34	33	33	34	34	33	34	32	31	32	33	33	31	33	34	34	33.39
	36	34	36	35	36	34	34	36	36	36	34	34	34	33	34	33	35	34	34	34	34	34	35	35	34	34	34	34	33	34	35	35	34.42
	48	37	37	37	37	37	37	37½	37½	37½	37½	37½	37	36	36½	36	36	37	36	37	37	37½	36	37	37½	37	36	37	37½	37	37	37	36.92
June	30	35	35	35	35	35	34	34	33	33	33	33	33	34	33	33	33	33	33	34	34	33	33	33	33	32	33	33	33	32	32	....	33.40
	36	35	35	35	35	36	34	34	33	33	34	34	34	34	34	33	33	33	34	34	34	34	34	34	34	33	33	34	34	33	33	....	33.90
	48	37	37	37	37	37	35	36	36	36	37	37	37	37	37	36	35½	36	36	37	36	36	36	36	37	36	36	36	37	36	37	....	36.42

Appropriations made for the Washington Aqueduct, with the dates of acts for the same.

Date.	Amount.	Date.	Amount.	Date.	Amount.
September 30, 1850	$500	March 3, 1869	$25,000	March 3, 1881	$20,000
August 31, 1852 *a*	5,000	July 15, 1870 *b*	120,822	July 1, 1882 *g*	20,000
March 3, 1853	100,000	March 3, 1871	114,196	March 3, 1883	20,000
March 3, 1855	250,000	June 10, 1872	70,555	July 5, 1884	20,000
August 18, 1856	250,000	January 23, 1873	14,000	February 25, 1885	20,000
March 3, 1857	1,000,000	March 3, 1873 *c*	43,600	July 9, 1886	20,000
June 12, 1858	800,000	June 23, 1874 *d*	36,400	March 3, 1887	20,000
June 25, 1860	500,000	March 3, 1875	26,000	July 18, 1888 *h*	20,000
July 4, 1864	150,000	July 31, 1876	22,000	March 2, 1889 *i*	20,000
July 28, 1866	142,584	March 3, 1877	15,000	August 6, 1890 *j*	25,500
December 20, 1866	12,000	June 20, 1878	15,000	March 3, 1891	20,000
March 2, 1867	20,000	March 3, 1879 *e*	20,000		
July 25, 1868	52,500	June 4, 1880 *f*	20,000	Total	4,050,657

NOTE.—Reverted to the Treasury: (*a*) $2.81, (*b*) $46.25, (*c*) $560.87, (*d*) 35 cents, (*e*) $1,109.87, (*f*) $381.06, (*g*) $1,354.17, (*h*) $2,266.34, (*i*) $4.12, (*j*) $5,500; total $11,225.84. This sum being deducted from the total amount appropriated shows the amount ($4,039,431.16) expended to June 30, 1892. Since 1878 one-half the amounts appropriated have been contributed by the United States and the other half by the District of Columbia.

AAA 2.

WATER SUPPLY, DISTRICT OF COLUMBIA.

THE 48-INCH MAIN.

The work of laying the 48-inch main, for which $575,000 was appropriated by the act of March 2, 1889, the laying the 30-inch mains in East Capitol street and in New Jersey avenue NW., and the 24-inch mains in Eleventh street NW., in K street NE., and in Eighteenth street NW., which were done by means of the same appropriation, had been completed at the close of the last fiscal year.

The remainder of the appropriation, amounting to $10,669.91, remaining in my hands, was turned into the Treasury on the 9th of September, 1891.

On the 16th of April, 1892, by direction of the Chief of Engineers, I made a report on House bill No. 2834, Fifty-second Congress, first session, being "A bill to reimburse the Mellert Foundry and Machine Company for money retained by the United States for failure to complete a contract within a specified time."

Money statement.

July 1, 1891, balance unexpended	$10,866.58
June 30, 1892, amount expended during fiscal year	196.67
July 1, 1892, balance unexpended	10,669.91
July 1, 1892, outstanding liabilities	81.40
July 1, 1892, balance available	10,588.51

It should be remarked that the outstanding liabilities on account of this appropriation are for services and for telegraphing that can not now be paid, for the reason, in the first case, that the men have never presented themselves and can not be found, and, in the second case, by reason of the suspension of the payment of bills for telegraphing on the public service. These liabilities when paid will have to be settled at the Treasury Department.

As far as can be foreseen the available remainder of the appropriation will not be required for future expenditure.

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AAA 3.

INCREASING THE WATER SUPPLY OF WASHINGTON, DISTRICT OF COLUMBIA.

This work was commenced under an appropriation made in the act of Congress approved July 15, 1882.

The plan consisted of raising the dam in the Maryland channel at the Great Falls of the Potomac to an elevation of 148 feet above mean tide at the Washington navy-yard and its extension at that height across Conns Island and the Virginia Channel of the river; extending the Washington Aqueduct from the distributing reservoir above Georgetown to the site selected for the new reservoir near Howard University by a tunnel 20,696.3 feet long; constructing at the tunnel outlet a new reservoir of about 300,000,000 gallons capacity, and connecting this reservoir by a new line of large mains with the existing system of water mains in the city of Washington.

All operations on this project are suspended, and no work has been done under it during the year.

The work of replacing the decayed timber linings of the upper portions of the tunnel shafts, which was in operation at the close of the last fiscal year, was continued, and completed early in the year. The work consisted in making an entirely new lining of the best quality of Georgia pine, extending either from the surface of the rock, as at Foundry Branch shaft (which was completed in the previous fiscal year), and Champlain avenue shaft, or from the top of the brick lining that had been carried at the Howard University shaft to within about 20 feet of the surface of the ground. At Foundry Branch shaft the new lining was of 3-inch plank set behind horizontal frames of 10 by 12-inch timbers 2 feet apart. At Champlain Avenue and Howard University shafts the lining was built solid of 10 by 12 inch timbers.

The interior stone lining, "pitching," of the new reservoir near Howard University having been considerably injured by drainage water from ground around the reservoir, which found its way to the bottom of the reservoir under the stone and undermined it, it was found necessary to cut off these streams, and several small retaining walls were built to prevent further damage. About 715 square yards of the stone lining of the reservoir which had sunk from the washing out of the sand under it was repaired. A guard strainer, 6 feet square, composed of 2-inch Georgia-pine plank, was built around the inlet mouth of the 12-inch drain under the dam to prevent a possible disastrous obstruction of this drain. A masonry wing wall was built on each side of the mouth of the great sewer which passes around this reservoir for its protection, and the earth which had been washed away was refilled back of the wall and over the sewer.

On February 20 I made a report on Senate resolution of February 16, 1892, inquiring into the expediency of completing and testing the Aqueduct Tunnel, and the report was printed in Senate Report No. 313, Fifty-second Congress, first session.

On May 25, in compliance with the directions of the Chief of Engineers, I made a report on Senate bill No. 3121, Fifty-second Congress, first session, being "A bill to amend an act approved July 15, 1882, entitled 'An act to increase the water supply of the city of Washington, and for other purposes;'" the object of the bill being to enable the Attorney-General and the Secretary of War to obtain a title for the United States, by right of eminent domain or otherwise, to such land

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and water rights at and above Great Falls as they may deem necessary for the present and future supply for the District of Columbia.

A watchman has been employed during the year at the new reservoir. His duties have included the guarding the stone at the mouth of all the shafts, except the one at Foundry Branch, which is under the care of the watchman at the distributing reservoir.

The following is a list of the appropriations for this work, with date of act for the same:

July 15, 1882	$1,485,279.30
July 7, 1884	87,500.00
March 3, 1885	87,500.00
March 26, 1886	5,000.00
August 4, 1886	555,000.00
March 30, 1888	355,000.00
Total	2,575,279.30

Money statement.

Title of appropriation.	July 1, 1891, balance unexpended.	June 30, 1892, amount expended during fiscal year.	July 1, 1892, balance unexpended.	July 1, 1892, outstanding liabilities.	July 1, 1892, balance available.
Land to extend aqueduct	$24,930.49		$24,930.49		$24,930.49
Extension of aqueduct	273,967.34	$1,863.45	272,103.89		272,103.89
Main connections	1,989.18		1,989.18		1,989.18
Land for reservoir	173.09		173.09		173.09
Constructing reservoir and gatehouse	83,184.81	1,603.49	81,581.32	$146.08	81,435.24
Water rights and land to extend dam at Great Falls	44,882.04		44,882.04		44,882.04
Completion and extension of dam at Great Falls	4,665.52		4,665.52		4,665.52
Aggregate	433,792.47	3,466.94	430,325.53	146.08	430,179.45

No estimate for further appropriation is submitted.

A A A 4.

ERECTION OF FISHWAYS AT GREAT FALLS.

At the commencement of the fiscal year operations were in progress under the contract entered into June 9, 1891, with Isaac H. Hathaway, of Philadelphia, Pa., for the construction of fishways at Great Falls, the plan and specifications for which had been prepared by the Commissioner of Fish and Fisheries, as contemplated by the act making appropriations for the same.

By direction of the Secretary of War the engineer officer in charge is held responsible only for the proper protection of the Aqueduct Dam at Great Falls and for the disbursement of the funds appropriated.

The Commissioner of Fish and Fisheries, having discovered that his plans for section 6 of the fishways were not adapted to the site of the work, new plans and specifications were prepared by him for this section, and on the 10th of September a supplemental contract was entered into with the contractor for the work under the new plans for section 6.

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By the terms of the contract the work was to have been completed before December 12, 1891, but the contractor, finding that this would be impracticable, asked for an extension of time to July 1, 1892, and this was granted him, the additional expense to the United States by reason of such extension being deducted on final settlement, as provided for in the contract.

By reason of the uncertainties as to the amounts of excavation, concrete, and riprap work that would be found to be required to completely finish sections 4, 5, and 6 of the fishways, and of a doubt whether all of this work and the superstructure of section 4 could be completed, as was greatly to be desired, before the next spring freshets, with the appropriation available for the fishways after paying the contractor the amount then due him (the contract provided that the excavation, the concrete, and the riprap was to be done at rates per cubic yard), it was deemed advisable to enter into a supplemental contract with the contractor to completely finish section 4 and to finish all the work remaining to be done on sections 5 and 6 at a lump sum which was within the amount of the appropriation remaining available. This agreement was entered into on the 22d of December, 1891.

There remains to be done sections 1, 2, and 3 to complete the fishways, for which the Commissioner will prepare modified plans, and for which $15,000 was included in the estimates submitted in my last annual report. This amount is again submitted.

The appropriations for this work to date are as follows:

Act of July 15, 1882	$50,000.00
Act of February 1, 1888	25,000.00
Total	75,000.00
Total disbursements to June 30, 1892	74,952.11
Balance unexpended	47.89

Money statement.

July 1, 1891, balance unexpended	$29.874.18
June 30, 1892, amount expended during fiscal year	29,826.29
July 1, 1892, balance unexpended	47.89
July 1, 1892, outstanding liabilities	2.93
July 1, 1892, balance available	44.96
Amount (estimated) required for completion of existing project	15,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	15,000.00

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APPENDIX B B B.

IMPROVEMENT AND CARE OF PUBLIC BUILDINGS AND GROUNDS IN THE DISTRICT OF COLUMBIA—WASHINGTON MONUMENT.

REPORT OF COLONEL OSWALD H. ERNST, U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

OFFICE OF PUBLIC BUILDINGS AND GROUNDS,
Washington, D. C., July 9, 1892.

GENERAL: I have the honor to submit the following report of operations upon public buildings and grounds under the Chief of Engineers in the District of Columbia, including the care and maintenance of the Washington Monument, during the fiscal year ending June 30, 1892:

MAINTENANCE OF IMPROVED PARKS.

The care required to maintain the various improved parks and park places in good condition has been extended during the year. The operations have consisted in mowing and raking lawns and destroying weed growth upon them; scuffling, raking, repairing, and rolling gravel walks and roads and edging their margins; cleaning gutters and drain traps; pruning trees and shrubs and removing web caterpillars and bagworms therefrom; maintaining pavements and asphalt roadways and walks in a cleanly condition, and planting, trimming, and caring for flower beds and inclosing them with light wire fences. In the autumn some of the beds were planted with chrysanthemums for fall blooming and others with early spring flowering bulbs. In May and June the beds and vases were stocked with flowering and ornamental foliage plants for summer decoration, and water lilies were planted in the basins of fountains.

GROUNDS NORTH OF THE EXECUTIVE MANSION.

The wide roadway east of the Navy Department was resurfaced with fresh gravel and a cobblestone gutter, 172 feet long and 3 feet wide, was laid along the west side of the roadway at its north end. Repairs were made to the asphalt pavement at the entrance to this roadway and to the asphalt roadway and approaches thereto, leading to the north front of the mansion. These repairs covered an area of 83 square yards.

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GROUNDS SOUTH OF EXECUTIVE MANSION.

The wide roadway south of the State Department was resurfaced with fresh gravel where required. Six large deciduous trees and 11 large evergreen trees were removed from the thickly planted groups in the southern end of park and replanted in the northwest corner, and 22 large flowering shrubs and 7 American elms were also planted in the latter part of the grounds, the trees being placed along the boundary line on Seventeenth street. The soil removed in these plantings was used in filling the low ground around the belt of trees which screens the President's stable. Two large Japan maples were also removed from this park and replanted in McPherson Square.

WASHINGTON NATIONAL MONUMENT.

The monument has been open to visitors daily, Sundays and holidays excepted, with the exception of one and one-half days in November, when operations which were in progress for the introduction of a new set of cables for the elevator caused the blocking of the entrance. The elevator has been run for the accommodation of visitors every day that the monument was open, with the exception of six days in August and three days in April, when repairs were being made to the boilers, and nine days in November, when the two new cables were being placed in position. The new cables are of steel wire, with hemp centers, and are each 1,060 feet long and 1½ inches in diameter. Grooves in the main and vibrating sheaves were turned out before the new cables were placed in position. The old cables were sold at public auction and the proceeds deposited in the Treasury. Monthly inspections of the elevator and its machinery were made by an agent of the builders, and daily inspections of the safety appliances on the elevator car were made by the employés at the monument before starting to carry passengers. The storm door and casing at the entrance to the monument and the window frames at the top were repainted. All of the presented tablets in the interior walls of the monument were cleaned, and the usual care required to maintain the interior of the shaft and its surroundings in a neat condition was extended. An apparatus for lubricating the elevator guides and a new sheave for governor rope of car were placed in position, a new section placed in the rope, and four compression oil cups for lubricating placed upon the main bearings of elevator drum. Necessary attention has been bestowed upon the electric-light plant, and three additional electric lamps have been placed upon the lower floor of the shaft. The electric lights have been in operation every day that the monument was open, with the exception of seven days in July, one in December, three in April, and one-half day in June, when repairs to the dynamo engine or the boilers were in progress. On those days the interior of the monument was lighted by the station oil lamps on the landings. Four galvanized-iron ventilators of small size were placed in the roof of engine house, the overhead ironwork and pipes in engine room repainted and a new water-pipe connection made, necessary repairs made to the dynamo engine, and a new drain valve placed on the cylinder of elevator engine. The two boilers were thoroughly cleaned twice during the year, a new set of tubes placed in Boiler No. 1, two new arch plates placed in the fronts of furnaces, the bottom blowpipe from boilers extended and connected with sewer, two new seats placed on safety valves, new packing placed on all valve stems, necessary repairs made to the main steam pipe, and the outside doors and casings of

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boiler house repainted. The ceilings and walls of rooms in lodge house were calcimined, the woodwork given a coating of hard oil, and the tin-roof covering repaired and repainted.

There were 156,870 visitors to the top of the shaft during the year, of which number 108,701 made the ascent in the elevator and 48,169 by the stairway, making a total of 613,175 persons who have visited the top since the monument was opened to the public on October 9, 1888. Numerous acts of vandalism occurred during the year, consisting principally in writing upon the walls and chipping and defacing the presented tablets. Arrests were made whenever the perpetrators were detected. The most flagrant act of this character was the removal of three of the four remaining silver letters from the "Nevada" stone. An unsuccessful attempt was made to remove the fourth letter, and to prevent that being carried off also, it was removed by the custodian and sent to this office. During an electric storm on June 27, 1892, the monument was struck by lightning. The current followed one of the lightning conductors in the shaft (which are the four hollow wrought-iron Phœnix columns standing in the well of the shaft and which support the elevator machinery and guide the car) to within about 20 feet from the floor, when it left the conductor and, in the form of a ball of fire as large as one's fist, struck an iron plate in the floor of the shaft. It then jumped to the heater pipe adjacent and continued through to the engine room, where the only damage done was the burning out of two electric lamps. It also charged the machinery with electricity, as the assistant steam engineer, who was in the act of opening a valve on the elevator engine, experienced quite a severe shock, but sustained no injury. Later (about 5:40 p. m.) on the same day the monument was struck a second time, when, as reported by the watchmen on duty, the current seemed to leave the conductor at the same place and explode on the floor.

WASHINGTON MONUMENT GROUNDS.

The work of grading the low grounds along B street north was continued during the first half of the year. About 10 acres were rough-graded, completing the grading of that portion of the grounds, excepting about half an acre near Fourteenth street, which was occupied by gravel and stone piles, etc. About 3,500 cubic yards of earth filling was received, without cost to the United States, from various persons who found these grounds a convenient dumping place, and used in grading. Of the newly graded ground $6\frac{1}{3}$ acres were sown down in grass seed. About 1,300 cubic yards of soil was used in surfacing a portion of the ground. The low ground east of the lodge house was graded, surfaced with soil, and seeded; 2,825 linear feet of cobblestone gutter, $2\frac{1}{2}$ feet wide, were constructed along the margins of roadways, 5 additional brick drain traps built and 8 raised to proper grade, 67 feet of 6-inch and 420 feet of 8-inch terra cotta drain pipe laid to connect the traps with main drains, and the edges of the lawn surfaces bordering the new gutters sodded. The driveway in front of the lodge, and portions of the new roadway north of the monument were coated with fresh gravel, 250 cubic yards of material being used for the purpose. A piece of roadway was constructed branching off from new drive and connecting with that entering from Fourteenth street, near B street north, and a triangular piece of lawn surface formed thereby was sodded. A foot walk 10 feet wide was constructed from the northeast corner of the monument to the entrance at Fifteenth and B street north,

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and an asphalt pavement 5 feet wide and about 585 feet long, covering an area of 325 square yards, laid on the center of same, the space on either side being constructed with gravel. A board walk about 320 feet long was laid from the terminus of this asphalt walk out to the Fifteenth street entrance.

GREENHOUSES AND NURSERY.

There are 16 greenhouses in the nursery grounds, numbered from 1 to 16, and covering an area of 24,787 square feet. There are also 2 brick potting sheds, 9 frame buildings used as shops and storehouses, 1 large lath hous eused for storing plants in the summer, 2 open sheds, and 766 feet of cold frames 6 feet wide. One hundred and eighteen feet of the cold frame and two of the frame buildings were constructed during the year. One of the new buildings is 18 by 20 by 25 feet and two stories high, and will be used as a storehouse. The other is 36 feet long, 12 feet wide, and 10 feet high, and will be used as a storehouse and toolhouse. The latter was not quite completed at the close of the fiscal year, the work remaining to be done consisting of covering the roof with tarred felt and glazing the window sashes. A frame building which was constructed during the previous year, but not quite finished, was completed in July, 1891, by laying a wooden floor on the first story and shingling the south side of roof. The entire superstructure of the large palm house, 22 by 24 by 100 feet, was rebuilt during the first part of the fiscal year, but during a severe storm on November 23 the house was blown down. The framework was lifted from the brick walls and carried a distance of 6 feet, striking against the ends of a range of greenhouses north of the palm house; the ridge timbers broke where jointed in center and about 40 feet of the roof fell in on the plants; 110 linear feet of the brick foundation wall was demolished and about two-thirds of the glass in the house was broken; 68 small and medium-size plants were totally destroyed and a number had their foliage broken and bruised. The work of rebuilding the house was immediately commenced and completed in December. The damage to the other greenhouses and cold frames consisted of the breaking of about 310 lights of glass, which were replaced. Necessary repairs were made to the several greenhouses during the year. In five of the greenhouses 1,049 linear feet of old staging, from 3 to 4 feet wide, was torn out and replaced by new material, and repairs made to that in other houses. The flues of boilers and furnaces were opened and cleaned, leaks in the joints of hot-water pipes repaired, and new air vents put in where needed; 255 feet of new beading and 4 new rafters were put in, 240 feet of 6-inch strips placed on benches, and 2,674 linear feet of additional temporary shelving for plants put up. New doors were placed in House No. 9, repairs made to the sashes in some of the houses and on cold frames, and minor carpentry repairs made as required. A plank floor was laid in one of the potting sheds, a closet for storing tools built in another, all broken glass in the greenhouses replaced by new, the roofs of three houses reputtied, and 8 new water tanks for the houses and 465 plant boxes made. A new frame was placed upon a brick pit 75 feet long and 6 feet wide, improvements made in two water closets, and a stationary wash basin placed in the office and necessary water and drain pipe run for its service.

During the autumn of 1891 about 6,682 chrysanthemums were sent out for planting in the various parks. There were planted in the greenhouses for winter bloom 2,076 roses, 367 begonias, 68 rose geraniums,

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5,187 carnations, 524 pansies, 153 heliotrope, 176 mignonette, and 166 acacias, a total of 8,717 plants; and for winter forcing there were potted and boxed 2,076 freesia, 500 Lilium Harrissii, 5,220 Roman hyacinths, 3,000 tulips, 1,993 Dutch hyacinths, 2,820 narcissus, 5,000 Convallaria majalis, and 400 clumps of Astilbe japonica; in all, 21,009. For early spring bloom there were planted 500 Lilium auratum bulbs, and in the cold frames 280 hardy pinks, 560 violets, and 544 pansies. There were purchased during the year 736 plants for the greenhouses and 45,989 bulbs for setting out in the parks and as stock for the nursery. During the winter and early spring months about 486,493 ornamental foliage and flowering plants, divided into 49 species and 359 varieties, were propagated, nearly all of which were set out in the parks during May and June. In the nursery the grounds were maintained in a neat and cleanly condition, attention bestowed upon the stock growing therein, and necessary transplanting done as required; 210 young trees and 611 shrubs were purchased and set out in the nursery for acclimation before final planting in the public grounds. During the year 110 young trees and 1,046 shrubs were lifted and planted in various parks. There were planted for stock and summer bloom 675 clumps of Astilbe japonica, 725 echeverias, 6,700 carnations, 62 dahlias, 193 geraniums, 48 roses, 15,210 tuberose bulbs, 400 gladiolas, and 230 chrysanthemums. The hedge on the north and east sides of the grounds was trimmed and the fence at the west end, which was blown down during a storm, was repaired, and 80 additional feet of 1¼-inch water pipe laid. The construction of a water-lily pond or basin in the nursery, which was commenced in June, 1891, was completed in July, 1891. A second pond has been constructed during the present year. It is 62 feet long, 15 feet wide, and 3 feet 5 inches deep, with 9-inch brick walls and brick bottom plastered with cement mortar.

SMITHSONIAN GROUNDS.

An asphalt footwalk covering an area of 166 square yards was laid upon the gravel path on west side of Army Medical Museum from the entrance at Eighth and B streets south, and the old plank walk on the west side of the National Museum was removed and replaced by an asphalt footwalk containing an area of 172 square yards, and the ground bordering the same raised to grade with soil and seeded. An asphalt pavement covering an area of 1,929 square yards was laid on the roadway in northwest part of grounds from its entrance at Tenth and B streets NW. to join the pavement heretofore constructed on that roadway, and the ground bordering the new pavement seeded; 420 linear feet of new brick gutter 20 inches wide were constructed along the margins of the new pavement, 155 linear feet of old gutters taken up and relaid, and 214 linear feet brought into line. There were also constructed about 87 linear feet of cobblestone gutter 30 inches wide. About 349 cubic yards of gravel excavated in constructing the new asphalt pavement and about 126 cubic yards removed from the vacant animal pens in rear of the Smithsonian Institution were used in repairing the roadways in park, and 105 square yards of old asphalt walk were resurfaced. An earth mound was constructed around the sarcophagus in front of National Museum and sodded, and an excavation 10 feet long, 4 feet wide, and 18 inches deep was made at the east end of the building to receive the cast of an Irish elk removed from the Museum. After the cast was set the ground around the same was sodded. A short gravel walk was constructed in front of the tool house, the bor-

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ders of some of the walks in the grounds sodded, and the ground bordering the asphalt walk from Twelfth street to the Smithsonian Institution was lowered to conform to the grade of that walk and resodded. The broken surface of the margins of the asphalt roadway from the institution building to Twelfth street was repaired and the asphalt pavement between the wings of the Army Medical Museum was resurfaced, the work on both having been done without expense to the United States under the provisions in the contracts which require the pavements to be kept in order for five years after construction. Repairs were made to some of the stake and wire fences erected to prevent trespassing, old plank was laid during the winter over bad places on footwalks, and three dead deciduous trees and eighteen half dead evergreen trees in the grounds were cut down and removed.

RESERVATION 101, VIRGINIA AND MARYLAND AVENUES, BETWEEN SEVENTH AND NINTH STREETS, SW.

In April a plank walk was laid across a portion of the reservation in the prolongation of Eighth street, crossing so much of the reservation as has not been appropriated by the Baltimore and Potomac Railroad Company.

HENRY AND SEATON PARKS.

About 200 cubic yards of gravel was used in resurfacing the roadways leading to the bridge across the railroad tracks on Sixth street, about 40 cubic yards were used in raising the grade of the walk near the railroad depot in Henry Park, the plank walk near the mound in that park was repaired, stake and wire fences to prevent trespassing were erected, and some of the old fencing repaired. In Seaton Park two half-dead peach trees and one dead willow tree were taken up and removed, repairs made to the gravel walks, and a new platform placed to the watchman's lodge. During the winter months old plank was laid over bad places on the walks in these parks.

GRANITE CURBING ABOUT LAFAYETTE SQUARE.

A curbing of dressed granite has been placed around Lafayette Square. The material was furnished and set under contract, while the work of opening trenches and restoring the ground after the curb was set was performed by workmen employed by this office. The total length of curb set was 1,899 linear feet of straight curb, with 93 linear feet of circular curb, and 16 terminal piers at the park entrances, excepting the entrance at southeast corner of park, where two granite-block piers with wing walls were constructed. Ornamental lamp-posts and gas lamps were erected on each of these two piers.

GRANOLITHIC PAVEMENT ON SIDEWALK ON PENNSYLVANIA AVENUE, IN FRONT OF EXECUTIVE MANSION GROUNDS.

The old flagging pavement on this sidewalk was taken up and replaced by a granolithic pavement, and the openings around the trees which stand along the center of the sidewalk were inclosed with granolithic curbing, the work being done under contract. The total area of pavement laid was 2,697 square yards and the total length of curbing constructed was 459 linear feet. After the curbing was placed the

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openings were filled with soil and sodded. That portion of the flagged pavement of the sidewalk on the east side of the grounds which joins the new granolithic pavement was taken up and lowered over an area of 9 by 24 feet to make it conform to the grade of the latter.

M'PHERSON SQUARE.

This square, situated at Vermont avenue and Fifteenth street, between I and K streets, NW., was entirely remodeled during the year. The iron post and chain fence inclosing it was taken down and removed. The material composing the old asphalt walks was excavated and removed and the openings left thereby filled up with earth and clay. The grade of the entire surface of park was raised, the ground surfaced with the soil which was removed when the new grading was commenced, and seeded. A mound of earth was constructed around the statue of General McPherson, covered with soil and sodded. New walks were constructed on more graceful lines, and an asphalt pavement covering an area of 1,100 square yards laid upon them, and their margins sodded. The drinking fountain and gas lamp combined was taken down and removed to Seaton Park, and the two in that park were removed therefrom and reërected in McPherson Square, one at the north side and one at the south side of the statue, and necessary water, drain, and gas pipe for their service laid and connected. Twenty-one large shade trees and seventy shrubs that were in the way of improvements were removed. Nine hundred and sixty linear feet of granite curb, removed from the reservations at Pennsylvania avenue, Fourteenth and E streets, NW., and Pennsylvania avenue, Twentieth and I streets, NW., were redressed and set in place around the square and a sod border laid on the inner side of curb.

JUDICIARY SQUARE.

Worn portions of the gravel roadways in this park were resurfaced. An asphalt pavement, covering an area of 338 square yards, was laid on the gravel roadway leading from Fourth street to east entrance to the Pension Office building, 30 feet of 20-inch cobblestone gutter relaid, and a line of new brick gutter laid at west end of the building. An asphalt footwalk was laid on the north side of the building and the asphalt walk running across the park from Fourth to Fifth streets along the line of E street was widened 3 feet for its entire length. In widening this walk it was found necessary to remove and rebuild two drain traps and take down and reset four lamp-posts which were on the line of the improvement. The total area of asphalt footwalk constructed in this park during the year was 639 square yards. Two crossings on the E street roadway were repaired, and 3 feet were added to the granite-block entrances of the two roadways leading to the court-house. A group of trees and shrubs was planted on the lawn at south front of Pension Office building, and a group was also planted around the new air duct on west side of court-house and the ground around the duct sodded. During the winter a plank walk 3 feet wide was laid along the east side of center roadway between the E and F street roadways, leading toward Pension Office. A new valve was placed on the water pipe supplying the watchman's lodge, and a new bowl placed in the closet in the lodge.

In view of the fact that the Twenty-sixth Annual Encampment of the Grand Army of the Republic is to be held in this city in September

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next, it was considered appropriate to make the floral display in the public grounds a little more elaborate this season than usual. Judiciary Square was selected as the best place for the purpose, and 30 additional flower beds have therefore been laid out in that park at the east, west, and south sides of the Pension Office building. The plantings of these beds are designed to represent the badges of the different army corps, and of the Grand Army of the Republic.

RESERVATION NO. 34.

This triangular reservation, situated on the north side of Pennsylvania avenue, between Seventh and Eighth streets W., was entirely remodeled during the year. The post and chain fence was taken down and removed. The grade of the reservation was raised, the ground surfaced with the soil which was removed to permit of the regrading, gravel walks constructed, and the triangle inclosed with a curbing of dressed granite. Sixteen large shade trees around the border were removed and tall branches cut from those remaining. The new lawn surfaces were seeded and their margins sodded, two large flower vases set in position, and the reservation planted with shrubs.

RESERVATIONS NORTH OF PENNSYLVANIA AVENUE AND WEST OF THE CAPITOL.

In Lafayette Square an asphalt footwalk covering an area of 50 square yards was laid on the gravel path west of the Lafayette statue and 257 square yards of old asphalt footwalk were resurfaced. In June a large and handsome group of palms and other foliage plants was made at the central entrance from Pennsylvania avenue upon the site originally selected for the statue to Gen. Lafayette, which was left bare by the removal to another location of the granite subbase of the pedestal for that statue.

In Franklin Square worn portions of the gravel walks were repaired and 207 square yards of asphalt walk were resurfaced.

Reservation No. 20, at the intersection of Pennsylvania avenue, Twenty-eighth, and M streets NW., was remodeled. An iron-post-and chain fence was erected around the triangle, the gravel walk around the fountain basin and the curb on the borders of same removed, the ground left open thereby filled up and converted into lawn surface and seeded down, the borders of the reservation sodded, and 31 shrubs planted.

In Washington Circle worn portions of the gravel walk were resurfaced, new brick gutters laid along their margins where there were bad washes, and six new brick drain traps built and connected with the main drains.

In Reservation No. 26, at the intersection of Pennsylvania avenue, Twenty-first, and I streets NW., 17 loads of gravel, removed from Reservation 20, were used in repairing gravel walks.

The granite coping which supported the high iron fences formerly inclosing the reservations at Pennsylvania avenue, Twentieth, and I streets, and Pennsylvania avenue, Fourteenth, and E streets NW. was taken up, redressed, and removed to McPherson Square; the reservations were cleaned up, and at Twentieth street the trench left open by the removal of the curb was filled in and the ground around the borders of the triangle regraded.

In Mount Vernon Square a plank walk 4 feet wide was laid from the

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northeast to the southwest corner of the square over the asphalt walks that are much worn.

The circle at the intersection of Massachusetts and New Jersey avenues and First and G streets NW., known as Reservation No. 74, was improved. It was inclosed with an iron post-and-chain fence, the soil on worn portions of the lawn surface loosened and sown down in grass seed, and twelve American linden trees planted around the border within the line of fence.

STATUE TO MEMORY OF GENERAL LAFAYETTE AND HIS COMPATRIOTS.

Two ornamental iron lamp-posts, with arc gas lamps, were erected upon the granite-block piers at the southeast entrance to Lafayette Square, one northeast and the other southwest of the statue to the memory of Gen. Lafayette and his compatriots.

PUBLIC RESERVATIONS OCCUPIED BY THE BALTIMORE AND POTOMAC RAILROAD COMPANY AND THE BALTIMORE AND OHIO RAILROAD COMPANY.

Attention is again invited to the fact that without authority of law, and in violation of section 223 of the Revised Statutes relating to the District of Columbia, the Baltimore and Potomac Railroad Company is now occupying reservations Nos. 101, 105, 109, 174, 177, 178, 241, and 309, and the Baltimore and Ohio Railroad Company is occupying Reservation 201.

This office has reported from time to time the facts of the occupancy of some of these reservations by the railroad companies, and the subject has been referred to the law officers of the Government, with the request that such action may be taken as will be necessary for the protection of the interests of the United States.

RESERVATIONS EAST OF THE CAPITOL.

In Reservation No. 17, Garfield Park, repairs were made to the gravel roadways, 43 trees and 170 shrubs were planted, and 2 dead trees and 4 dead shrubs removed from the eastern section of the park.

In Lincoln Park repairs were made to the gravel walks, and the plumbing of the closet in watchman's lodge was repaired.

In Stanton Park temporary plank walks were laid during the winter over wet places on the gravel paths.

Repairs were made to the gravel road in Marion Park.

PARK SETTEES, COMPOST, TOOLS, AND REMOVING SNOW AND ICE.

During the year 329 park settees were repaired and about 300 repainted, stakes with irons for fastening down settees were made, and loose settees in various parks were refastened in position.

Three hundred and forty-nine cubic yards of stable manure and 570 cubic yards of soil were purchased, thoroughly mixed, and the compost thus formed was spread upon the lawns of various parks during the winter and raked in in the spring. Twenty tons of Peruvian guano was also purchased, mixed with soil, and sown over the lawns of various parks where the manure compost had not been spread.

The various tools and appliances used in prosecuting the work upon

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the public grounds were kept in good repair, and purchases of new tools were made from time to time as required.

During the winter the snow and ice were removed from the walks through the various parks and the pavements surrounding them after each storm, excepting the last storm of the season in March, when the balance of the appropriation remaining on hand was not sufficient to do all of the work required. On that occasion only one-half the width of the pavements and walks of the more prominent parks could be cleaned (excepting those in front of the Executive Mansion, which were entirely cleaned), and the pavements of Rawlins Square, Reservation No. 101, three circles and twenty-one triangular reservations could not be cleaned at all. In January this office recommended that an additional appropriation of $1,000 be made for use during the remainder of the season, and an estimate for that purpose was duly submitted to Congress. The funds, however, were not provided.

CONSTRUCTING, REPAIRING, AND PAINTING IRON FENCES, CONSTRUCTING STONE COPING ABOUT RESERVATIONS, PAINTING VASES, ETC.

Iron post-and-chain fences were erected around Reservation No. 20, at Pennsylvania avenue, Twenty-eighth, and M streets NW., and Reservation No. 74, at Massachusetts and New Jersey avenues, First and G streets NW., and granite coping was placed around McPherson Square and Reservation 34, on the north side of Pennsylvania avenue, between Seventh and Eighth streets NW. Necessary repairs were made to the iron post-and-rail fence around the triangular reservation on Massachusetts avenue, between Third and Fourth streets NW.

The high iron fence of the grounds at the north front of the Executive Mansion, the lamp-posts and lamps in Smithsonian grounds, Henry and Seaton parks, Franklin, Lafayette, Lincoln, Stanton, Folger, and Marion parks, and the inclosed grounds south of Executive Mansion, the iron post-and-chain fence inclosing Judiciary Square, and the lamp-posts and lamps therein, were repainted, as were also the iron post-and-chain fences inclosing the reservations at Massachusetts and New Jersey avenues, First and G streets NW.; New York avenue, First and M streets NW.; Pennsylvania avenue, Twenty-eighth and M streets NW.; and a portion of that inclosing Farragut Square. Ten iron vases in different parks were painted, and those in McPherson Square were varnished. The walls of the watchmen's lodges in Franklin, Judiciary, and Lincoln squares were cleaned, pointed up, and calcimined, the new caps on the iron fence posts of reservations on Pennsylvania avenue, between Fourth and Ninth streets east, were painted, and a number of sign boards for use on park lawns and roads and some small signs for designating trees and shrubs were painted and lettered.

WATER PIPES, FOUNTAINS, AND GAS LAMPS.

Attention was paid to the water pipes in the public grounds during the year and such repairs made as were required. In the autumn the water was shut off from the pipes, the hose valves removed therefrom and stored in the nursery shops, and during the winter the valves were examined and those requiring it repaired; in the spring they were replaced upon the pipes and the water turned on. Additional lines of water pipe were laid, as follows: In the Executive Mansion grounds 360 feet of $1\frac{1}{2}$-inch pipe, with two hose valves and two street washers; in Reservation No. 158, at New York avenue, First and M streets, NW., 168

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feet of 2-inch pipe, 3 feet of 1¼-inch pipe, one 2-inch shut-off valve, and one 1¼-inch hose valve; in Reservation No. 74, at Massachusetts and New Jersey avenues, First and G streets, NW., 53 feet of 2-inch pipe, 6 feet of 1¼-inch pipe, two 2-inch shut-off valves, and one 1¼-inch hose valve; in the Monument grounds, 170 feet of 2-inch pipe, 3 feet of 1¼-inch pipe, and one 1¼-inch hose valve; in the Nursery grounds, 80 feet of 1¼-inch pipe and two 1¼-inch hose valves. The standpipe for the hose valve and the stopcock box in the reservation on north side of Pennsylvania avenue, between Seventh and Eighth streets, were raised to conform to the new grade of the grounds, four of the old shut-off valves in as many different reservations were removed and replaced by new valves, and a fish trap was placed upon one of the mains in the Monument grounds to prevent fish getting into the pipe supplying water to the engine room and boiler house of the Washington Monument. That portion of the pipe line which supplies the Executive Mansion with water from the Franklin Square spring which lies on New York avenue, between Fourteenth and Fifteenth streets, was changed from the middle of the avenue to the south side, and at Fifteenth street it was lowered and a blow-off pipe placed upon it, in order to get the line out of the way of the construction of the new cable road, the work being done by the Washington and Georgetown Railroad Company without cost to the United States. Breaks in other parts of this pipe line were repaired by this office. Complaint having been made of a disagreeable and nauseating taste to the spring water supplied to the Capitol, a sample of the water was analyzed by Acting Assistant Surgeon W. M. Mew, U. S. Army, through the courtesy of the Surgeon-General of the Army. The analysis showed the water to be of exceptional purity. Old and unserviceable hose valves were replaced by new valves as needed, and 3,600 feet of new rubber hose was purchased to replace old hose no longer serviceable.

Necessary attention was paid to the fountains. The bottom of the basin of large fountain north of Executive Mansion was recoated with cement, the joints of the stone coping grouted, and the large jet repainted; eight additional brick receptacles for holding soil for water lilies were built in the basin of fountain south of the Mansion, necessary repairs made to the basin and to the 4-inch valve controlling the water supply of the fountain west of the Mansion. The basins of the fountains in Franklin Square and Iowa Circle were repaired, obstructions removed from waste pipe of the latter, new overflow pipes placed in the basins of fountains at Pennsylvania avenue and Ninth street, NW. and New York avenue and Tenth street NW., and a new shut-off valve placed on the pipe supplying the latter. The old waste pipe of the fountain in Sherman Park was taken up and replaced by new pipe and repairs made to the jets, overflow pipes, and strainers of various fountains as required. Two drinking fountains in Seaton Park were taken down and reërected in McPherson Square, and one in the latter square was removed therefrom and placed in Seaton Park. New shut-off valves were placed in position for the drinking fountains in Judiciary, Rawlins, and Mount Vernon squares, Washington Circle, and the two reservations at Massachusetts avenue and Eleventh street NW., and obstructions were removed from the waste pipes of those in the two reservations last mentioned and of one in the Smithsonian Grounds. Repairs were made to the drinking fountain in Washington Circle and those in the Smithsonian grounds, Henry and Seaton parks, Judiciary, Franklin, Lafayette, Lincoln, Farragut, and

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McPherson squares were repainted, and the two in the latter park were varnished.

Two additional lamp-posts and lamps were erected in Judiciary Square upon the line of the F street roadway and the positions of four lamp-posts on the E street roadway were changed. A new top and lamp were placed upon one of the lamp-posts in the Smithsonian grounds. The gas lamps in the various parks were maintained in good condition during the year, broken glass in the lanterns being replaced by new as required. The average number of single burners lighted nightly during the year was 309.

EXECUTIVE MANSION, GREENHOUSES, AND GROUNDS.

In the basement corridor and small pump room the old wooden base boards and old stone flagging were removed, new floors and base boards of Portland cement constructed, floors of similar material laid in the elevator pump and tank room and in the old storeroom, and the walls of all these apartments scraped and calcimined. Two new partitions, each 24 feet long and 10 feet high, were erected to separate the elevator pump and tank room and the old storeroom from the hallway between, and a new wooden floor was laid in the tank room. The large water filter was removed from the basement corridor and placed in a small room opposite the tank room, and necessary connections made with the system of pipes. A new storage closet was constructed in the basement, repairs made to the windows and doors and to the kitchen ranges, larger pipes introduced for furnishing the bath rooms with an increased supply of rain water, and necessary pipe run and connected for supplying hot water to the executive offices. In the laundry the old floor was removed, a tile floor upon a concrete foundation laid, the walls tiled to a height of 5 feet from the floor, a new iron sink and new soapstone washtubs placed in position, and new galvanized hoods placed over the latter, a dry closet for drying clothes, a new steam boiler for operating it, and a new soapstone clothes boiler, also to be operated by steam, placed in position. The old floors of the two small rooms adjoining the laundry were taken up, concrete foundations laid and new wooden floors placed upon them, and the walls and ceilings of the rooms scraped and calcimined. In the servants' bathroom in basement the floor and lower part of walls were laid in tiles, a new bathtub put in, the walls and ceilings scraped and calcimined, and the woodwork repainted. On the first floor the walls and ceiling of the hall between east room and entrance vestibule, and of the hall on second floor above and the stairways and landing between, were painted and decorated, the cornices tinted, and the woodwork varnished. The walls and ceilings of the green parlor, the state dining room, and the entrance vestibule were redecorated and the woodwork repainted, new window shades, curtains, and laces hung, and new carpets laid in the two former rooms; new carpet laid in the east room, and the furniture of that room reupholstered and recovered. A new service of glassware and some new decorated china tableware for the state dining room were purchased. The ceilings of the elevator landings on first and second floors were papered and the walls painted, the walls of the elevator shaft calcimined, the pipes in shaft painted, repairs made to the elevator, the car cleaned and refinished in hard oil, and the network on elevator landings rebronzed. On the second floor the walls and ceilings of the southwest bedchamber were repapered, the cornices tinted and the woodwork painted, and a new portable grate was placed

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in the fireplace of one bedroom. In the southwest bath room the old bath tub and closet were replaced by new ones, a new tile floor laid, the wooden partition faced with marble slabs, two large marble slabs set in place back of the bath tub, and the walls and ceiling and woodwork painted. In the large bath room at north front the closets, old bath tubs and plumbing were taken out, new pipes introduced, the floor and lower part of walls tiled and marble door jambs and sills put in, the closets replaced, two new bath tubs, one foot tub and two marble-top washbasins set in place, and the walls scraped and painted. The walls and ceilings of the closet adjoining the elevator landing were also painted. New carpet was laid in the upper corridor and on the elevator hall. In the autumn all carpets were relaid and curtains rehung, and in the spring the carpets were removed from the floors, the curtains taken down and the rooms arranged for the summer. Repairs were made to the tin roof of the mansion and to the copper leaders therefrom, and improvements were made in the running of the overflow pipe from large water tank in garret. The chandeliers were overhauled and cleaned, repairs made to gas fixtures and plumbing arrangements, and necessary attention paid to the electric-lighting fixtures. The exit bridge, storm house, and cloak boxes used at official receptions were repaired and painted, or stained, as required, and the boxes renumbered. Repairs were made to some of the furniture and some new floor linen was purchased. New sash chains were placed to those windows requiring them and minor carpentry repairs made as required. The bases of columns and the lamps on the north portico were repainted. A severe storm which visited this city on November 23 last did considerable damage to the mansion. About 30 linear feet of the stone balustrade above the cornice on the east end of the building was blown down, and in its fall crushed a portion of the east porch. The porch was restored so far as the condition of the stones would permit, but its completion and the restoration of the balustrade will have to be deferred until additional funds are provided by Congress. The telegraph, telephone, and fire-alarm wires, which were also thrown down, were replaced.

The work of introducing wires and fixtures for electric lights, which was not quite finished at the close of the fiscal year 1891, was completed during the early part of the present fiscal year. Chandeliers were hung in the pantry and in bedrooms not hitherto provided with them. An additional fixture was placed on the ceiling of Red Room, wall brackets put up in State dining room and switch wires run, and glass placed upon some of the chandeliers. Wires were run and lamps placed in the laundry, and in the propagating and camelia greenhouses, and the conservatory was completed. Two chandeliers in one of the rooms on second floor were taken down, rehung in other rooms, and two new chandeliers were placed in the former room. A storeroom in the basement was wired and two additional brackets were placed in lower corridor, at entrance to conservatory. A meter for recording the quantity of electric current furnished the Mansion from the dynamos in the State, War and Navy Departments building was purchased and placed in position. The lead covering of one of the three cables conveying the current to the Mansion having become corroded in places, it was taken out of the conduit, cleaned, encased in rubber hose and replaced. A new cable was also placed in the conduit for use in place of another of the original cables that was not working satisfactorily.

At the stable of the Mansion an addition, 36 feet deep and 38 feet wide, to the shed between the carriage houses was constructed and

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closed in at the end with a wood and glass partition with sliding doors. A new tin roof was placed upon the old part of the shed and a new slat walk laid over a portion of it. Some minor carpentry and glazing repairs were made in the stable and slight repairs made to its slate roof. About 35 square yards of the asphalt pavement at the west front of the stable was repaired and 32 square yards of the pavement adjoining the doors of the shed between the carriage houses was taken up and relaid in such manner as to prevent the water from running under the doors.

Necessary repairs were made to the greenhouses. In the large rose house a new bench, 82 feet long and 4 feet wide, consisting of an iron frame with slate slabs was erected, 3 new doors, 4 new posts, 12 new rafters, 70 feet of new sill, 60 feet of 8-inch facia, and some new scroll ridge plate and eaves plate put in, and the east end of house and 46 sash repaired. In the small rose house 2 new posts and 24 feet of 8-inch facia were put in and the east end of the house repaired. In the camelia house, 10 new posts, 42 feet of new sill, 9 new sash, 100 feet of new beading, 70 feet of new plate, 63 feet of facia, and 22 feet of eaves board put in, and 3 sashes repaired. The old boiler of this house was replaced by a new one, which was walled in, the flues, pipe, and smokestack cleaned, and about 30 feet of new pipes put in. In the conservatory, 9 new rafters with facia and moldings, 1 new girder, 1 new center post, 160 feet of new plate, and 225 feet of new facia put in, 5 large roof sash repaired, 104 ventilating sash taken down, eased and rehung, the interior of the building repainted, and 2 new breastplates put in the large steam boiler which heats the house. Some new tin gutters and down spouts were also placed upon the conservatory and camelia house. Two large doors were hung at the entrances to potting room, and in the water-closet under conservatory the old wood floor and wainscot was removed and replaced by a floor of Portland cement, and a slate wall plate set back of and a slate sill set under the urinals. Repairs were made to two cold frames, the old smokestack on propagating house replaced by a new stack of galvanized iron, and a new boiler purchased and placed in position for heating the grapery in place of the old one that had become unserviceable. A flagstone walk 374 feet long was laid south of large rose house, east and south of camelia house, and south and west of grapery. Necessary attention was bestowed upon the large collection of plants, and desirable varieties for decorating the grounds were propagated; 17,575 bulbs of different varieties were purchased for winter forcing and for planting the flower beds for early spring bloom. The storm of November 23, already referred to, did some slight damage to the greenhouses, 215 lights of glass having been broken, and 4 sashes blown from the cold frames. The damage was promptly repaired.

The grounds were maintained in good order during the year, necessary attention being paid to the lawns, walks, gutters, trees, and shrubs. In the autumn nearly 43,000 hyacinth, tulip, and crocus bulbs were planted in the flower beds for early spring bloom. In the spring these were removed and replaced by about 35,000 bedding plants for summer decoration.

TELEGRAPH TO CONNECT THE CAPITOL WITH THE DEPARTMENTS AND GOVERNMENT PRINTING OFFICE.

The entire line was overhauled, all slack wire pulled up and cut out, new cross arms placed on poles where needed and the wires well insulated; fourteen new poles were erected at different points along the line

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to replace old poles, which were in a decaying and dangerous condition, and which were removed. New cross arms were placed upon the new poles, the wires attached, and one-half mile of new wire put up in place of old wire that had become unserviceable. In July, 1891, the lineman of this office superintended the lowering of the three United States telegraph cables at Pennsylvania avenue and First street NW., and First and B streets NW., to get them out of the way of the construction of the cable road of the Washington and Georgetown Railroad Company, all materials and labor expended in the work having been paid for by the railroad company. The old fixtures on the roof of the Department of Agriculture were removed and replaced by new ones. New fixtures were placed upon the roof of the Winder building, and new fixtures and cable boxes placed upon the roof of the Executive Mansion in place of those demolished by the storm of November 23. Damages to the wires of the line by that storm were also repaired. The main battery in this office and the local batteries and instruments in the Departments were maintained in effective working order. The instruments that had been removed from the tables of the operators in the Senate and House of Representatives and stored in this office during the recess were replaced and reconnected prior to the reassembling of Congress. Some old and unserviceable wire on the roofs of the Post-Office Department building and the Patent Office building was removed and replaced by new wire. In May, 1892, the office of the Interstate Commerce Commission was connected with the line, the cost of the work being paid by that office.

Attention is again respectfully invited to the fact that it is becoming more and more difficult to operate the overhead telegraph system, owing to the fact that the trees along the line are gradually growing up into the wires and interrupting the continuity of the electric currents, particularly during wet and windy weather. Not only have the present poles become too short, but many of them are rotting at the butts and are in constant danger of breaking from their own weight or of being blown down during storms. The necessity for either replacing the overhead wires by underground cables or of replacing the present poles by taller ones is obvious. An estimate for placing them underground is herewith submitted. An alternate estimate for placing them overhead is also submitted.

SURVEYING AND DRAFTING.

The draftsman of public buildings and grounds is also custodian of the old records of the city of Washington in charge of this office, and his time is mainly taken up with their care. He is required to exhibit them to owners of city property, to lawyers and real estate agents, and to produce them frequently in court. For at least half of the past fiscal year he has been engaged in searching these old records and preparing extracts from the same for use as evidence in the case of the United States *vs.* Morris *et al.*, and in examining the printed proofs of his evidence in that case and comparing that evidence with the facts as shown by the old records. He has been engaged in surveying and preparing plats of reservations numbered 20, 21, 22, 32, 33, 34, 56, 57, 70, 71, 72, 73, 74, 132, 133, 134, 135, 136, 144, 151, 152, 153, 170, 171, 172, 173, 268, and 274 so far as the improvements are completed, and has completed plats of Iowa Circle, McPherson Square, and Judiciary Square, and reservations numbered 26, 27, 28, 29, 37, 38, 39, 40, 41, 42, 43, 66, and 67.

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In order that the draftsman may devote his whole time to surveying the public grounds and making the plans of them that are required by law to be kept in this office, a clerk should be provided to take charge of the old records, and the estimate submitted last year for that purpose is again presented and recommended.

Attention is again invited to the fact that there is reason to believe that a large number of lots in this city to which the United States has a clear title are held and occupied by private persons. It is of much importance that this office should be provided with the clerical force necessary to investigate this subject.

Estimates for the fiscal year ending June 30, 1894.

Salaries of employés, public buildings and grounds, etc.:		
One office clerk	$1,600	
One messenger	840	
One public gardener	2,000	
One clerk in charge of old public records of Washington City	1,500	
One clerk	1,400	
One electrician and telegraph lineman	1,000	
Overseers, draftsmen, foremen, gardeners, mechanics, and laborers	30,000	
One captain of the watch	1,200	
One day watchman in Lafayette Square	660	
One day watchman at Franklin Square	660	
Two day watchmen in Smithsonian grounds, at $660 each	1,320	
Two night watchmen in Smithsonian grounds, at $720 each	1,440	
One day watchman at Judiciary Square	660	
One night watchman at Judiciary Square	720	
One day watchman at Lincoln Square and adjacent reservations	660	
One day watchman at Iowa Circle	660	
One day watchman at Thomas Circle and neighboring reservations	660	
One day watchman at Washington Circle and Rawlins Square	660	
One day watchman at Dupont Circle and neighborirg reservations	660	
One day watchman at McPherson and Farragut squares	660	
One day watchman at Stanton Square and neighboring reservations	660	
Two day watchmen at Henry (Armory) and Seaton squares, at $660 each	1,320	
One night watchman at Henry (Armory) and Seaton squares	720	
One day watchman at Mount Vernon Square and adjacent reservations	660	
One day watchman at grounds south of the Executive Mansion	660	
One watchman for greenhouses and nursery	660	
One day watchman for Marion Square, Folger Square, and adjacent reservations	660	
One day watchman at Garfield Park	660	
One night watchman at Garfield Park	720	
		$55,680
Contingent expenses public buildings and grounds		500
Improvement and care of public grounds:		
Improvement of grounds north of Executive Mansion	1,000	
Improvement and maintenance of grounds south of Executive Mansion	4,000	
Ordinary care of greenhouses and nursery	2,000	
Ordinary care of Lafayette Square	1,000	
Ordinary care of Franklin Square	1,000	
Care and improvement of Monument grounds	10,000	
Continuing improvement of reservation No. 17 and site of old canal northwest of same	5,000	
Construction and repair of post-and-chain fences, repair of high iron fences, and constructing stone coping about reservations	1,500	
Manure, and hauling same	5,000	
Painting watchmen's lodges, iron fences, vases, lamps, and lamp-posts	1,000	

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Improvement and care of public grounds—Continued.

Purchase and repair of seats	$1,000	
Purchase and repair of tools	2,000	
Trees, tree and plant stakes, lime, whitewashing, and stock for nursery	3,000	
Removing snow and ice	1,500	
Flowerpots, twine, baskets, wire, splints, moss, and lycopodium	1,000	
Care, construction, and repair of fountains	1,500	
Abating nuisances	500	
Improvement, care, and maintenance of various reservations	20,000	
Improvement, maintenance, and care of Smithsonian grounds, etc	8,000	
Improvement, care, and maintenance of Judiciary Square	7,000	
Granite curbing about Franklin Square	5,000	
Laying asphalt walks in various reservations	5,000	
Improvement and care of Henry and Seaton parks	5,000	
Constructing an ornamental fountain in Lafayette Square upon the site originally selected for the Lafayette statue	4,000	
Replacing the old flagging pavement of the sidewalks in the grounds north of the Executive Mansion by a granolithic pavement	2,500	
Construction of a large greenhouse at the propagating gardens for palms and tropical plants of large growth, needed for trophical bedding, etc., in the public parks during the summer months	6,000	
Improvement of Howard University Park (Reservation No. 246)	5,000	
Laying an asphalt pavement upon the roadway east and south of the State, War, and Navy Department building	15,000	
		$124,500

Care of, repairs, fuel, etc., Executive Mansion:

Care, repair, and refurnishing the Executive Mansion, to be expended by contract or otherwise, as the President may determine	25,000	
Fuel for Executive Mansion, greenhouses, and stable	3,000	
Care and necessary repair of greenhouses	5,000	
Renewing the superstructure of one greenhouse connected with the Executive Mansion	1,500	
Repairs to conservatory, Executive Mansion	2,000	
		36,500

Lighting the Executive Mansion and the public grounds:

Gas; pay for lamplighters, gas-fitters, and laborers; purchase, erection, and repair of lamps and lamp-posts; purchase of matches, and repairs of all kinds; fuel and lights for office and office stable, for watchmen's lodges, and for greenhouses at the nursery: *Provided*, That for each 6-foot burner not connected with a meter in the lamps on the public grounds no more than $21.50 shall be paid per lamp for gas, including lighting, cleaning, and keeping the lamps in repair, under any expenditure provided for in this act; and said lamps shall burn not less than 3,000 hours per annum; and authority is hereby given to substitute other illuminating material for the same or less price, and to use so much of the sum hereby appropriated as may be necessary for that purpose	15,000	
Electric lights for 365 nights, from 7 posts, at 40 cents per light per night, $2.80 per night	1,022	
Erecting 8 iron posts in the Monument grounds, connecting them with underground wires for electric lights, and supplying electric lights for the same	2,000	
		18,022

Repairs to water pipes and fire plugs:

Repairing and extending water pipes, purchase of apparatus for cleaning them, purchase of hose, and for cleaning the springs and repairing and renewing the pipes of the same that supply the Capitol, the Executive Mansion, and the building for the State, War, and Navy Departments		5,000

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Telegraph to connect the Capitol with the Departments and Government Printing Office:		
Replacing the present system of wires with a duplicate 6-conductor underground cable, being a total distance of about 6,625 linear feet	$31,000	
(An alternative estimate, amounting to $1,600, is also submitted for replacing the present poles with new and taller poles, and if an appropriation for that purpose be made it should be accompanied by authority to erect the poles.)		
Care and repair of existing lines	1,500	
		$32,500
Total		272,702

Washington Monument, elevator, electric lights, and machinery connected therewith. The following estimate for operating the elevator, the electric lights and machinery connected therewith for the fiscal year ending June 30, 1894, is submitted:

One custodian, at $100 per month	$1,200
One steam engineer, at $90 per month	1,080
One assistant steam engineer, at $70 per month	840
One fireman, at $60 per month	720
One assistant fireman, at $60 per month	720
One conductor of elevator car, at $75 per month	900
One attendant on floor, at $60 per month	720
One attendant on top floor, at $60 per month	720
Three night and day watchmen, at $60 per month each	2,160
Fuel, lights, oil, waste, packing, tools, matches, paints, brushes, brooms, lanterns, rope, nails, screws, lead, electric lights, heating apparatus, oil stoves for elevator car and upper and lower floors, repairs to engines, boilers, dynamo, elevator, and repairs of all kinds connected with the Monument and machinery, and purchase of all necessary articles for keeping the Monument, machinery, elevator, and electric-light plant in good order	3,600
Total	12,660

As some of the foregoing estimates are larger than the amounts heretofore appropriated, and as others are for new work, it is deemed advisable to submit the following brief explanation in reference thereto:

First.—One public gardener, $2,000. I have asked for an increase in the salary of the public gardener, a position now so satisfactorily filled by Mr. George H. Brown. The duties of the office require that the gentleman who fills it shall be thoroughly skilled in the culture of trees, shrubs, and plants, and shall have a practical knowledge of civil engineering as applied to landscape gardening. Mr. Brown combines these attributes, to which he adds taste, industry, and integrity. His duties take him from one end of the city to the other. He is directly responsible for the care of the valuable collection of plants in the propagating garden, and superintends the propagation of plants that are annually raised for the public grounds, which this year numbered about 486,000.

Second.—One clerk in charge of old public records of Washington City, $1,500. These records include maps, deeds, record books, letters, etc., from the organization of the original board of commissioners, near the close of the last century, up to 1867, when the duties were turned over to the Chief of Engineers. They are constantly examined by attorneys and others interested in lands in Washington, and the person in charge of them is frequently required to produce them in courts; to index them properly, to be able to turn at once to the details of any question raised, requires familiarity with every paper. This work has for the last few years been intrusted to the only draftsman allowed this

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office, and during the past year at least one-fourth of his time has been actually employed on this duty. It is desirable that this appropriation be made in order that the draftsman may be permitted to attend to the necessary and legitimate duties of his office.

Third.—One clerk, $1,400. Of late years the office work has increased to such an extent that to properly perform it has required continuous work at night and on Sundays and holidays. This is a hardship, and as a remedy an appropriation for an additional clerk is recommended.

Fourth.—For one telegraph lineman, $1,000. The telegraph system under charge of this office includes about 8 miles of overhead wire and 2.6 miles of underground cable. There are eighteen offices connected with these lines, the main battery being at this office. The lineman is constantly engaged in the care of the main and local batteries and such necessary repairs and extensions as a system of wires of this kind requires. He is industrious, efficient, and capable, and has won the confidence of all with whom he has come in contact by faithful attention to his duties.

Fifth.—An estimate for a captain of the watch is submitted and recommended. Such an officer is much needed in order that the park watchmen may be under proper supervision.

Sixth.—Estimates for a day watchman for Marion and Folger squares and adjacent reservations, and for a day watchman for Garfield Park, are submitted and recommended. Marion and Folger squares contain an aggregate area of about 3 acres, and Garfield Park contains an area of about 24 acres. They are highly improved, and the necessity for providing watchmen for their care is apparent.

Seventh.—For the care and improvement of the Monument grounds, $10,000. It is desirable that this important improvement should progress more rapidly than heretofore. The amount ($2,500) appropriated for 1893 will be sufficient merely to maintain the park in its present condition, and will not admit of any improvements in the unfinished portions of the grounds.

Eighth.—For trees, tree and plant stakes, etc., and stock for nursery, $3,000 is asked in place of the $2,000 last granted. The larger sum is the amount appropriated annually for more than twelve years ending June 30, 1892.

Ninth.—For removing snow and ice the sum of $1,500 is asked. The sum usually granted, viz, $1,200, is generally sufficient, but sometimes is not. The latter was the case during the last fiscal year, as mentioned in my annual report.

Tenth.—Twenty thousand dollars is asked for improvement, care, and maintenance of various reservations, in place of the $12,000 granted this year. It is proposed to improve as many as possible of the 200 unimproved reservations; each year from one to five are added to the list of improved reservations, and if the funds now requested become available eight or ten can be added during the fiscal year ending June 30, 1894. As reservations are thus improved the expense of the care of the whole is slightly increased, for the improvements must be maintained.

Eleventh.—For the Smithsonian grounds $8,000 is asked, and for Judiciary Square $7,000, in place of $5,000 and $3,000 granted this year. The increased amounts can be profitably expended during the fiscal year ending June 30, 1894, in the improvement of those parks.

Twelfth.—For placing granite curbing about Franklin Square $5,000 is asked. The beauty of this handsome park will be greatly enhanced by placing around it a granite curbing similar to those used around parks of the same style in the larger cities elsewhere.

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Thirteenth.—For laying asphalt walks in various reservations, $5,000. It is proposed to replace with first-class asphalt walks the gravel paths in Washington Circle, Mount Vernon Square, Executive Mansion grounds (south side), Lincoln Square, Stanton Square, Folger Square, Marion Square, Henry and Seaton parks, and to renew those in Farragut Square. In the late fall, winter, and early spring these walks are muddy and pedestrians seek the lawns, which are thus destroyed by trespassers. The amount of these paths which it is proposed to lay this year is about 3,500 square yards. Each autumn it becomes necessary to put down plank walks, which must again be removed in the spring. If asphalt walks are laid the annual expense incident to plank walks will be avoided.

Fourteenth.—For improvement, care, and maintenance of Henry (Armory) and Seaton Parks, $5,000. These reservations, extending from Seventh street to the Botanic Gardens, cover an area of 34 acres, with road and walk surfaces of over 10,000 square yards. They are in an advanced state of improvement. Their beauty has been marred by the depot and tracks of the Baltimore and Potomac Railroad. A mound has been constructed around the depot upon which it is intended to plant trees and shrubs, so that in time the depot will be hidden partially from view. The materials for this mound have thus far been obtained free of expense to the United States, and it is now proposed to grade the mound and to seed and plant it. The funds requested are needed for this purpose and for the care of roads, lawns, gutters, etc., and laying out additional paths.

Fifteenth.—For constructing an ornamental fountain in Lafayette Square, upon the site originally selected for the Lafayette statue, $4,000. This space is on the Pennsylvania avenue side of the square, directly opposite the Executive Mansion. The old foundation made for the pedestal of the statute can not be removed without considerable expense, but can be utilized for the foundation of a basin for an ornamental fountain, for the erection of which this estimate is submitted.

Sixteenth.—For replacing the old flagging pavement of the sidewalks in the grounds north of the Executive Mansion by a granolithic pavement, $2,500. These sidewalks lead from the entrance gates on Pennsylvania avenue to the north front of the Executive Mansion. The old flagging at present composing them is in bad condition and should be replaced by a granolithic pavement.

Seventeenth.—An estimate amounting to $6,000 is also submitted for constructing a large greenhouse at the propagating gardens for palms and subtropical plants. The greenhouse structures now existing at the gardens are of small size and not of sufficient capacity to accommodate that class of plants.

Eighteenth.—An estimate amounting to $5,000 is submitted for improving Reservation No. 246, known as Howard University Park. This park contains an area of about 11½ acres and is unimproved.

Nineteenth.—An estimate amounting to $15,000 is submitted for laying an asphalt pavement upon the roadway east and south of the State, War, and Navy Departments building. The present gravel roadway is objectionable both in wet and dry weather.

Twentieth.—The sum of $1,500 is requested for renewing the superstructure of one of the greenhouses connected with the Executive Mansion. The present structure is weak and should be rebuilt at the earliest opportunity.

Twenty-first.—An estimate of $2,000 for repairing the conservatory of the Executive Mansion is submitted. The structure is old and in

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bad condition and requires extensive patching to preserve the plants which it contains.

Twenty-second.—The estimate for the item for "gas, pay of lamplighters, etc.," under the title "Lighting the Executive Mansion and the public grounds," has been increased from $14,000 to $15,000. In the appropriation act for the fiscal year ending June 30, 1892, the amount to be paid per annum for lighting, etc., each gas lamp in the public grounds was increased from $20 to $21.50. To provide for this increase, for the additional amount that it is estimated will be required for the care and maintenance of the electric lamps and wires recently introduced into the Executive Mansion, and for the purchase of new gas lanterns to replace old lanterns in the public grounds as they become unserviceable, the additional $1,000 is asked.

Twenty-third.—An estimate of $2,000 is submitted for erecting eight iron posts in the Monument grounds, connecting them with underground wires for electric lights, and supplying electric lights for the same. Since the introduction of electric lights in the grounds south of the Executive Mansion the travel after nightfall through that park has increased. Much of this travel passes through the Monument Grounds, which are not now provided with any system of illumination.

Twenty-fourth.—The estimate for repairs to water pipes and fire plugs has been increased from $2,500 to $5,000. The sources of the spring which supplies the United States Capitol with water were much impaired by the excavations made in connection with the construction of the large reservoir near the Howard University for the increase of the city's supply of Potomac water, which has resulted in diminishing the pressure at the Capitol. It is proposed to use the additional amount requested in making connection with the strongest springs in the vicinity and in overhauling and repairing the old pipe line and renewing such portions of it as may be found unserviceable.

Twenty-fifth.—An estimate is again submitted for replacing the overhead wires between the Capitol and the departments with a duplicate underground six-wire cable. The growth of the trees on the sidewalks renders it absolutely necessary, in order to maintain telegraphic communication over these wires, either to erect at once taller poles at a cost of about $1,600 or to lay an underground cable at a cost of $31,000. It appears to be the will of Congress that no more overhead wires shall be placed in this city (see District of Columbia appropriation act of July 18, 1888); otherwise I should recommend the appropriation of the smaller amount.

Twenty-sixth.—I recommend that the salaries of the two steam engineers at the Washington Monument be increased from $80 and $60 to $90 and $70 per month, respectively. The duties of these two men are of great importance. Upon their efficiency and intelligence depend, to a great extent, the lives of those who use the elevator. The increase asked is small and the men deserve it. I also recommend that the pay of the two firemen be placed at $60 per month each. That is the rate allowed firemen in the Executive Departments, and there appears to be no reason why the firemen at the monument should receive less.

The item for fuel, lights, oil, waste, repairs, etc., should be increased from $3,000 to $3,600 for the purpose of painting the ironwork in the interior of the monument.

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Financial statement for fiscal year ending June 30, 1892.

Title of appropriation.	Available at beginning of fiscal year.	Expended during fiscal year.	Unexpended balance to revert to the Treasury.
Improvement and care of public grounds, 1892	$73,950.00	$73,831.22	$118.78
Repairs, fuel, etc., Executive Mansion, etc., 1892	43,000.00	42,975.16	24.84
Lighting, etc., Executive Mansion, etc., 1892	15,024.80	14,998.47	26.33
Repairs to water pipes and fire plugs, 1892	2,500.00	2,486.30	13.70
Telegraph to connect the Capitol with the departments and Government Printing Office, 1892	1,250.00	1,250.00	....
Contingent expenses public buildings and grounds under Chief Engineer, 1892	500.00	499.46	.54
Salaries of employés public buildings and grounds under Chief Engineer, 1892	49,060.00	49,018.40	41.60
Care and maintenance of the Washington Monument, 1892	12,820.00	12,497.34	322.66
Electric-light plant, Executive Mansion	2,076.00	2,076.00	....

I am, general, very respectfully, your obedient servant,

O. H. ERNST,
Colonel, U. S. A., Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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APPENDIX C C C.

ISSUE OF PUBLISHED CHARTS OF THE NORTHERN AND NORTHWESTERN LAKES, AND SURVEYS MADE FOR THE PURPOSE OF KEEPING THESE CHARTS UP TO DATE.

REPORT OF COLONEL O. M. POE, CORPS OF ENGINEERS, BVT. BRIG. GEN., U. S. A., FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 16, 1892.

SIR: I have the honor to transmit herewith, in duplicate, my annual report on the "issue of the published charts of the Northern and Northwestern Lakes and surveys, made for the purpose of keeping these charts up to date," for the fiscal year ending June 30, 1892. * * *

Very respectfully, your obedient servant,

O. M. POE,
Colonel, Corps of Engineers, Bvt. Brig. Gen., U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

C C C I.

ISSUE OF THE PUBLISHED CHARTS OF THE NORTHERN AND NORTHWESTERN LAKES AND SURVEYS, MADE FOR THE PURPOSE OF KEEPING THESE CHARTS UP TO DATE.

The sundry civil act of March 3, 1891, appropriated the following amounts for the fiscal year ending June 30, 1892:

Survey of Northern and Northwestern Lakes.—For printing and issuing charts for use of navigators and electrotyping plates for chart printing, two thousand dollars.
For surveys, additions to, and correcting engraved plates, ten thousand dollars.

Under the first item the issuing of charts has been done in Detroit, Mich., from this office; the rest of the work required being attended to by the office of the Chief of Engineers in Washington. During the fiscal year nearly all charts have been sold at the uniform price of 20 cents each. A few special lithographic charts have been sold for 10 cents each, and some charts have been issued free of charge for the official use of Government agents applying for them.

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The following table shows the extent of this business:

Issue of the charts of the Northern and Northwestern Lakes during the fiscal year ending June 30, 1892.

Description.	Number.	Total.
On hand July 1, 1891	7,835	
Received during year	3,139	
		10,974
Issued to United States vessels and officials	669	
Sold at 20 cents each	5,113	
Sold at 10 cents each	19	
		5,801
On hand July 1, 1892		5,173

The sum of $1,024.50 was turned into the Treasury from sales of charts.

Total number of charts distributed to July 1, 1891	181,186
Distributed during fiscal year	5,801
Total distributed to July 1, 1892	186,987

Complaints are often made of the quality of the paper on which the charts are printed. This paper is too easily torn and is not suited to the rough handling frequently necessary when the charts are used on shipboard. A better quality of paper could be furnished if more funds were available, and, in view of the great use made of these charts by the lake marine, an estimate of $3,000 is made for this item for the fiscal year ending June 30, 1894, in order that those who buy the charts from the Government may have this cause of complaint removed.

Under the second item of the above appropriation a number of charts have had corrections and additions made upon them in this office, and have been forwarded to Washington in order that the necessary changes might be made upon the engraved plates.

The following charts have thus been amended in this office:

	Scale.
Lake Superior, No. 3	1:400000
River St. Marie, No. 1	1: 40000
River St. Marie, No. 2	1: 40000
Straits of Mackinac	1:120000
North end of Lake Michigan	1:400000
Beaver Island Group, Lake Michigan	1:120000
Lake Huron	1:400000
Saginaw Bay, Lake Huron	1:120000
Saginaw River	1: 10000

The information embodied in the above charts was derived from the best available sources of information. Much assistance was obtained from the engineer office of the ninth and eleventh light-house districts and from engineer offices for the improvement of rivers and harbors. In some cases certain special examinations of the localities had to be made, and these were done in connection with works of river and harbor improvement in progress at the time. This work has been seriously impeded by lack of sufficient funds. The work is essential, however, if the charts are to be used for navigating the lakes.

Instructions from the Chief of Engineers require that if information of any obstructions to navigation not exhibited on the charts should be received, the same shall be communicated to the office of the Chief of En[illegible] with an estimate of the cost of a survey. Among other ob-

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structions so reported during the fiscal year were two shoals in the western end of Lake Erie, lying close to the course of vessels from Cleveland and eastern ports to the mouth of the Detroit River. One of these obstructions was reported about 3 miles north and west of Pelée Spit light-house, on the Canadian side of Lake Erie; the other was reported as making out from Littles Point near Colchester, Lake Erie, and was said to be due south of the wharf at Colchester and three-eighths of a mile outside of a shoal which was shown on the chart. An estimate of $1,000 was submitted for the survey of the former shoal and of $610 for the latter. On account of the large commerce passing these obstructions they were considered to warrant a special examination, and accordingly orders for the survey of these shoals were issued; for the shoal off Littles Point on September 25, 1891, and for the shoal off Pelée Spit light-house on November 19, 1891.

During the fall of 1891 there was too much unfavorable weather to warrant an attempt to survey the shoal off Littles Point, and the order directing a survey off Pelée Spit light-house was issued too late in the season to permit anything to be done until spring; nothing but preparatory work was done, therefore, until May 20, 1892, when a lake survey party, under the immediate charge of First Lieut. Charles S. Riché, Corps of Engineers, U. S. Army, left Detroit for Colchester, Ontario. Here most of the shore work was finished, and on May 25 the party proceeded to Pointe Pelée, Ontario, where all of the topographical and hydrographical work was completed, and the party returned to Colchester on June 14. A new shoal was discovered to the north and west of Pelée Spit Light-house, upon which but 13½ feet of water was found. One of the shoalest spots was over a wreck said to be the *Nicholls*, sunk in 1879, after the former survey of this locality had been completed. The importance of having all such dangerous shoals plotted upon the charts at the earliest possible moment after they are discovered is shown by the fact that a vessel is reported to have grounded upon the newly discovered shoal near Pelée Spit light-house shortly after the survey party left Pointe Pelée, and to have been delayed for sometime and subjected to considerable expense before getting off. All of the delay and expense thus incurred would probably have been saved had the shoal been marked upon the chart at the time.

The Lake Survey party under charge of Lieut. Riché, after their return to Colchester remained there until June 30, and just managed to complete their work by the close of the fiscal year; when, by operation of law, all moneys unexpended revert to the Treasury, and if no new appropriation is available work must stop. At Colchester work on the shoal making out from Littles Point was much interrupted by unfavorable weather. No new shoal was discovered, and it was demonstrated that no shoal existed in the place reported. The shoal shown on the chart, however, was found to be much more extensive, and to consist of sand, mud, and clay, in which a large number of bowlders are embedded. A minimum depth of 12½ feet was found where 16½ feet is shown on the chart. Had it not been for the use of the sweeping bar, however, very little change from the condition of the bottom at the time of the former survey would have been discovered, as the sounding poles and lead lines invariably showed from 4 to 6 feet more water than was found by the bar.

The cost of the survey off Pelée Spit Light-House was $553.09, and of the survey off Littles Point $587.59, the total being $1,140.68. Lieut. Riché's report is hereunto appended, marked A, and in it will be found

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more detailed information in regard to the work done, and the results accomplished by this party.

In my last annual report I stated that "many of the charts now issued are based upon surveys made thirty and thirty-five years ago, notably the two charts of St. Marys River, the surveys for which were made between 1853 and 1857." After some correspondence upon the subject, I was directed by the Chief of Engineers, under date of December 18, 1891, to submit an estimate for a resurvey of St. Marys River, including the drawing of the original charts, with the view to engraving the same for the series of lake charts—the new charts to cover the space between White Fish Bay and Point Detour Light, and to connect with the triangulations at both extremities. In accordance with these instructions, a project for such a survey was submitted on February 17, 1892, and the following estimate was made:

Planning triangulation	$1,000
Building stations	1,500
Measuring angles	4,500
Measuring bases	1,200
Astronomical observations	1,000
Hydrography	20,000
Topography	5,000
Precise levels	500
Office work	18,700
20 per cent for contingencies	10,680
Total	64,080

I also stated that "the foregoing estimate may be reduced in proportion as the work is made less complete; but I feel sure that a satisfactory survey, with the required office work to prepare the data for the engraver, can not be made for less than the above estimate, and think it more likely to cost a greater than a less amount, especially if we should have to extend the triangulation to the Straits of Mackinac, in order to make a suitable connection."

The above estimate did not include an item for the purchase of instruments, because all of these that would be required could be obtained from the Engineer Depot at Willets Point, N. Y.

Upon the receipt of the above project the Chief of Engineers, under date of February 23, 1892, directed me to submit a project for the expenditure of the available balance of the appropriation of March 3, 1891, in commencing the survey.

At that time the available balance was $6,461.72, and on March 2, 1892, a project for the expenditure of this sum was submitted. This project contemplated hydrographic work at the twenty-seven different points in the river where excavation has been done since the river improvement survey of 1879 was made; selection and measurement of a base line, planning triangulation, building stations and measuring as many angles as possible, running lines of precise levels; astronomical work, such as the determination of azimuth, and possibly of the latitude and longitude of one station, and a limited amount of topographical work.

This project was approved by the Chief of Engineers on April 7, 1892, with the statement that the available balance had been reduced to $4,461.72 by an allotment of $2,000 for a survey of the frontage of Chicago, to permit proper buoying for the convenience of steamers carrying passengers during the World's Fair, this latter survey being under the direction of Capt. W. L. Marshall, Corps of Engineers, U. S. Army, the officer in charge of the river and harbor district that includes Chicago.

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Upon the approval of the project for the commencement of the survey of St. Marys River, a requisition for the requisite instruments was forwarded to the Engineer Depot at Willets Point, N. Y., and steps were at once taken to secure a suitable assistant engineer to take immediate charge of the field work. This would have been an easy matter had it not been for the fact that all unexpended funds reverted to the Treasury at the close of the fiscal year. It was impossible, therefore, to offer anyone much more than two months' employment, and as an engineer of the necessary qualifications was likely to have permanent employment elsewhere, he would hardly wish to give up his position for the sake of remaining with the survey for so short a time. A suitable assistant was found, however, in the employ of the Missouri River Commission, Mr. O. B. Wheeler, who was formerly an assistant engineer on the Lake Survey, and the Commission having courteously consented to permit him to accept employment on the survey during this emergency, he reported for duty on May 22, bringing with him the base measuring apparatus used by the Missouri River Commission, which had been kindly loaned to the survey for the purpose of beginning the work as soon as possible.

The survey was placed under the general charge of Assistant Engineer E. S. Wheeler, who had prepared the projects, and whose long connection with the Lake Survey and familiarity with its methods and with the region in question peculiarly fitted him for the duty. He was so busy, however, with his regular work on the improvement of St. Marys Falls Canal and River, as to be prevented from attending to the field work in person. This duty devolved on Assistant Engineers O. B. Wheeler and Joseph Ripley, the latter having been transferred temporarily from the work of improving Hay Lake Channel, St. Marys River.

The shore work was made under the immediate charge of Assistant O. B. Wheeler. A base line about 2 miles in length was measured on Portage avenue in Sault Ste. Marie, Mich., and a steel tape belonging to the St. Marys River Improvement was standardized by comparison. The triangulation was planned starting from the base line through six stations, and the angles at four of these stations were satisfactorily measured. Observations were made for primary azimuth, a line of precise levels was run from a bench mark on the wall of St. Marys Falls Canal Lock to Bay Mills, which is far enough out to be on the Lake Superior level, and a water gauge was established at the latter point. Readings on this gauge indicate a fall in the water between Bay Mills and the head of St. Marys Falls Canal of 0.42 of a foot.

The hydrographic party under the immediate charge of Assistant Joseph Ripley began operations on May 27 in the vicinity of Sailors Encampment. Five stations were selected and marked and the triangulation of the river improvement survey of 1879 was carried to the head of Mud Lake. The hydrographic work done was practically the same as in making estimates in an improved channel. The center line of a channel was selected, making but one course from the angle above the shoal to the can buoy in Mud Lake instead of three courses as at present. Two posts were placed on St. Josephs Island in prolongation of this center line, and were located from two triangulation stations. From the coördinates thus obtained, the equations of center and side channel lines were computed with reference to the system of coördinates adopted for use in the improvement of the river. Cross-section stakes were driven on either side of the channel thus laid out, and, by means of marked lines stretched across the channel between these

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stakes, soundings 10 feet apart were taken within the channel lines and an area 400 feet in width and 3,120 feet in length was thus covered, Soundings were also taken 30 by 200 feet apart from the channel lines to the shore lines. Water-gauge readings were taken every quarter hour while sounding, and hubs were located along both shores in line with each pair of section stakes. In this work the maximum amount of use was made of all work of similar character that had been done in connection with the improvement of the river, and duplication of Government work was avoided. The United States tug *Myra*, with the quarter boat and other plant pertaining to the river improvement, was loaned to the survey, and everything done to facilitate obtaining the maximum results from the funds available.

Mr. E. S. Wheeler's report of operations on the survey of St. Marys River during the fiscal year ending June 30, 1892, is hereunto appended, marked B, and reference is made to it for detailed information.

The following instruments were forwarded from the Engineer Depot to Messrs. T. S. and J. D. Negus, of New York, for repairs, and were shipped by them to Sault Ste. Marie, Mich.:

1 chronometer, T. S. & J. D. Negus, No. 1524; 1 chronograph, Bond & Son, No. 316.

The following instruments were repaired in a similar manner by Messrs, F. E. Brandis, Sons & Co., of Brooklyn, N. Y., and shipped to Sault Ste. Marie:

1 Wurdeman Zenith telescope, No. 12; 1 Wurdeman astronomical transit, No. 1; 1 Troughton & Simms theodolite, No. 1, with 14-inch limb; 1 Troughton & Simms theodolite, No. 3, with 14-inch limb.

Use was also made of such of the instruments pretaining to the river improvement as could be spared, and everything is now in readiness for pushing the survey as rapidly as funds become available. The commerce using the river is so extensive that it is very important that the new charts be completed at the earliest possible date, in order that use may be made of the work already done, and in order that the available channels and courses may be known to the navigators of the large and expensive vessels that use this great highway of commerce.

The survey of St. Marys River was under the general charge of Assistant E. S. Wheeler. Assistant O. B. Wheeler had immediate charge of the shore work, and was assisted by Messrs. E. B. Wheeler, G. E. Balch, A. O. Wheeler, and E. G. Thomas. Assistant Joseph Ripley had immediate charge of the hydrographic work, and was assisted by Messrs. F. C. Shenehon and L. P. Morrison. The amount expended on this work during the fiscal year was $3,590.27, all of the unexpended portion of the allotments of $1,610 for the shoals in Lake Erie being available for this purpose, in addition to the balance of $4,461.72 referred to above. Out of this total amount of $6,071.72 an additional amount of $714.55 was expended for office expenses; so that the total expenditure was $5,445.50, leaving a balance of $626.22.

During the fiscal year several projects have been submitted with a view to rendering the charts of the Great Lakes of the greatest possible use to navigators. Under date of September 17, 1891, was proposed:

(1) A revision of all existing charts in regard to light-houses, fog signals, buoys, ranges, sailing lines, etc.

(2) Monthly publication during season of navigation of bulletins giving all aids to navigation not on charts; reports of dangers derived from vessels' logs; location of wrecks; water levels, state of harbors, etc.

(3) At close of each season of navigation all engineer officers in charge of river and harbor works to send to the office charged with the

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proposed duty charts with the condition of their works platted thereon; also any other information which may have come to their knowledge, including lights, buoys, range lines, sailing lines, etc., etc. The information thus obtained to be compiled upon the published charts during the winter.

(4) Examinations to be made of newly discovered obstructions of limited areas.

Under date of October 10, 1891, the following scheme for new charts to complete the set for the American coasts of the lakes was proposed, each chart named to be published on a single sheet:

GENERAL CHARTS.

	Scale.
Lake Superior Canal to Duluth	1:600,000
Lake Michigan Straits to Chicago	1:600,000

COAST CHARTS.

Lake Superior.

	Scale.
Outer Island L. H. to Duluth	1:120,000
Marquette to Portage Canal	1:120,000
Portage Canal to Outer Island L. H	1:120,000
Pointe Au Sable to Marquette	1:120,000
White Fish Point to Pointe Au Sable	1:120,000
North Shore from Duluth eastward	1:120,000

Lake Huron.

	Scale.
Pointe Aux Barques L. H. to Thunder Bay Island L. H	1:120,000
Thunder Bay Island L. H. to Detour L. H	1:120,000

In the above list the several charts are arranged in the order of their importance. St. Marys River was included in the scheme because more or less field work would have to be completed before new charts of this locality could be published.

These projects or something of a similar nature will have to be carried out if the charts are to be rendered of the greatest service to navigators. The work already done, particularly in the location of the dangerous shoals in Lake Erie above referred to, has fully demonstrated the necessity which exists for work of this character. The lake marine is of too great importance to the country at large for any effort looking towards its safety to be spared. When the United States Government sells charts to navigators, these charts should embody the latest and most accurate information concerning the localities to which they refer, and everything should be done to render navigation safe and certain.

From 1885 up to the opening of navigation in 1892 the lowest water surface of the lakes for the season has been less each year than the year before. This condition, however, is only temporary and evidences now point to an increase in depths. Combined with this lowering in recent years, however, has been the great growth of the lake vessels both in size and number, a growth that must be seen to be appreciated. Since the original surveys were made the maximum draft of vessels has increased from 9½ and 12 feet to 16 feet, and when improvements now in progress are completed it will be still further increased to 20 feet. As a consequence the larger and more expensive vessels are constantly discovering dangers previously unknown, and discovering them by the costly process of striking them. All dangers so discovered should at once be surveyed and located upon the charts in order to prevent the

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repetition of similar accidents at the same point. Localities deemed perfectly safe for navigation when smaller vessels were used are now regarded with suspicion by the larger vessels and it is essential that certain special areas should be reëxamined.

Navigation of the lakes is attended with peculiar dangers, similar in kind, but far different in degree, to those met with upon the ocean. On the lakes vessels are never far from land and, what is worse, have land all around them. Running before a gale is never to be thought of. At certain seasons of the year gales are frequent and severe, and at all times an accurate knowledge of the locations of all dangerous obstructions is essential to safety. Accurate knowledge of this kind can be obtained in but one way and that is from the charts. It is essential, therefore, that all the charts be kept constantly up to date.

The commerce passing through St. Marys River now amounts to 9,000,000 tons of freight, and that through the Detroit River to over 20,000,000 tons of freight, annually, and this commerce is increasing with great rapidity. Interests of such magnitude require that no stone shall be left unturned for their protection.

The survey of St. Marys River has been begun, and everything is in readiness to push the work so that new charts of this locality may be published at the earliest possible date. The records of the former survey and of the river improvement will prevent alld uplication of work and will permit the survey to be done as quickly as possible. The organized districts in connection with river and harbor work now established at the chief cities on the lakes will greatly facilitate keeping all the charts up to date and will insure the maximum results with the minimum cost.

In view of the great importance of this work to the lake marine, an estimate of $50,000 for "surveys and other expenses connected with correcting and extending the charts of the northern and northwestern lakes" during the fiscal year ending June 30, 1894, in addition to an estimate of $3,000 for "printing and issuing charts for the use of navigators and electrotyping copper plates for chart printing" is submitted, in full confidence that the conditions now existing amply warrant this expenditure.

Estimate for the fiscal year ending June 30, 1894.

For printing and issuing charts for the use of navigators and electrotyping copper plates for chart printing	$3,000
For surveys and other expenses connected with correcting and extending the charts of the northern and northwestern lakes	50,000
Total	53,000

Money statement.

Allotted	$6,071.72
June 30, 1892, amount expended during fiscal year	1,402.66
July 1, 1892, balance unexpended	4,669.06
July 1, 1892, outstanding liabilities	4,042.84
July 1, 1892, balance available	626.22
Amount that can be profitably expended in fiscal year ending June 30, 1894.	53,000.00

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Dates and amounts of appropriations for survey of northern and northwestern lakes.

March 3, 1841	$15,000	July 20, 1868	$75,000
May 18, 1842	20,000	March 3, 1869	100,000
March 1, 1843	30,000	July 15, 1870	100,000
June 17, 1844	20,000	March 3, 1871	175,000
March 3, 1845	20,000	June 10, 1872	175,000
August 8, 1846	25,000	March 3, 1873	175,000
August 12, 1848	25,000	June 23, 1874	175,000
March 3, 1849	10,000	March 3, 1875	150,000
September 28, 1850	25,000	July 31, 1876 (not including $16,000 applied to survey Mississippi River)	84,000
March 3, 1851	25,000		
August 30, 1852	25,000		
March 3, 1853	50,000	March 3, 1877 (not including $25,000 applied to survey Mississippi River and including $9,500 received from sale of steamers)	94,500
August 5, 1854	50,000		
March 3, 1855	50,000		
August 30, 1856	50,000		
March 3, 1857	50,000		
June 12, 1858	75,000	June 20, 1878 (not including $49,500 applied to survey of Mississippi River	49,500
March 3, 1859	75,000		
June 21, 1860	75,000		
March 2, 1861	75,100	March 3, 1879	85,000
July 5, 1862	105,000	June 16, 1880	40,000
February 9, 1863	106,879	March 3, 1881	18,000
July 2, 1864	100,000	August 17, 1882	12,000
February 28, 1865	125,000	March 3, 1883	3,000
June 12, 1866	50,000		
March 2, 1867	77,500	Total	$2,942,879
March 2, 1868	77,500		

Dates and amounts of appropriations for survey of northern and northwestern lakes.

Printing and issue of charts for use of navigators and electrotyping copper plates for chart printing:	
July 7, 1884	$3,000
March 3, 1885	3,000
August 4, 1886	2,000
March 3, 1887	2,000
October 2, 1888	2,000
March 2, 1889	2,000
August 30, 1890	2,000
March 3, 1891	2,000
Total	18,000

Dates and amounts of appropriations for survey of northern and northwestern lakes.

Surveys and additions to and correcting engraved plates:	
March 2, 1889	$5,000
August 30, 1890	10,000
March 3, 1891	10,000
Total	25,000

A.

REPORT OF LIEUTENANT CHAS. S. RICHÉ, CORPS OF ENGINEERS.

COLONEL: I have the honor to submit the following final report of operations of the lake survey party under my charge at the shoal 3 miles north and west of Pelée Spit light-house and at the shoal making out from Littles Point, Lake Erie.

PROGRESS.

The preparatory work of fitting out the party was done during the first part of May, 1892; and on May 20 the party left Detroit in the steamer *Scotia*, which had been engaged for the survey, and arrived at Colchester, Ontario, off which place is

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situated the shoal making out from Littles Point. Here most of the shore work was done, and on May 25 the party proceeded to Pointe Pelée, where shore work was finished; and on May 28 hydrographic work was begun on the shoal 3 miles north and west of Pelée Spit light-house, where 3½ fathoms are shown on the chart. This shoal was completely resurveyed by June 1, and a new shoal about half a mile northeast of this one was discovered; by June 6, although interrupted somewhat by heavy weather, considerable progress had been made upon the survey of the newly discovered shoal, when the steamer *Scotia* disabled her boiler and had to leave the work for repairs. Mr. Charles L. Smith, one of the party, was sent with her, with instructions to secure the services of another steamer should repairs to the *Scotia's* boiler take too much time. In the mean while an effort was made to continue the survey of the shoal by means of a small boat alone. The boat, however, was loaded so deep and the locality was so exposed, being 3 miles from the nearest land, that the boat had to run for shore every time a squall threatened, and it was impossible to make much progress. On June 11, however, Mr. Smith returned with the tug *C. W. Wells*, and hydrographic work at this point was soon finished.

On June 14, 1892, the party left Pointe Pelée for Colchester via Kingsville, at which latter place it was necessary to communicate with the post-office. While there a hasty survey was made of the harbor, in order that new docks, lights, etc., erected since the former survey might be located upon the chart. There is a harbor of refuge at this point available for small craft, which has been constructed in recent years; and a large summer hotel, the Mettawas, now stands upon the shore of the lake and forms a prominent landmark. It was expected that the harbor would be deepened to about 14 feet by dredging during the coming summer; and during the return of the party to Detroit a Canadian dredge and outfit, said to be bound for Kingsville, were passed at Amherstburg.

The party arrived at Colchester on June 14, and on the following day located the shoal that is shown on the chart about a mile south of the dock. During this day it was ascertained that the steamer *Scotia* was expected back from Detroit with a new boiler, and authority was obtained by telegraph to reëmploy the *Scotia* upon her arrival and discharge the *C. W. Wells*, as the *Scotia* was a very much more suitable boat for the work required and was much cheaper. Later in the day, however, it was ascertained that the *Scotia* had not had a new boiler placed in her, as the boiler the owner had expected to obtain had proved too large, and it was therefore supposed that the work would have to be completed with the tug *C. W. Wells*.

At Pointe Pelée the steamer had been obliged to seek shelter each night at Pelée Island or Kingsville, owing to the lack of shelter from sudden gales in the vicinity of the work. At Colchester similar conditions existed, and the steamer was obliged to seek shelter at Amherstburg, near the mouth of Detroit River, where also she could keep herself supplied with coal. On the evening of June 15 Recorder Herman Kallman, jr., went to Amherstburg with the *Wells*, expecting to return with her early the next morning. When the *Wells* arrived at Amherstburg her engineer deserted on account of the long hours he had been necessarily obliged to keep, and Mr. Kallman saw at once that if the work were to be pushed another tug must be secured immediately, and that there was no time for the owner of the *Wells* to secure another engineer. Mr. Kallman therefore took the responsibility of discharging the *Wells*, and spent the greater part of the night endeavoring to secure another boat, going as far as Wyandotte in a rowboat for the purpose, but to no avail. He finally found the *Scotia*, which had just returned to Amherstburg, and, thinking that if she was in good enough condition to go from Detroit to Amherstburg she would be able to do all the work that was needed by the survey, persuaded her owner to return to Colchester with him in the morning. Thereafter she remained with the party until the close of operations, and, although partially disabled, performed her work in a more satisfactory manner than it would have been possible for the *Wells* to do.

Work at Colchester, on the shoal making out from Littles Point, was very much delayed by bad weather. The situation is such that all but a nearly due north wind makes too much sea to permit of accurate work, and in fact of any work at all that requires the use of the sweeping bar. By June 24, however, all work on the shoal proper was completed, and by the end of June 26 only one more day's work was needed to surround the shoal thoroughly with soundings, and there remained four days more before the close of the fiscal year, when all funds would revert to the Treasury. June 27, 28, and 29 were too stormy to permit the steamer to get to the shoal, or to permit work after she got there. June 30, the last day on which work was possible, opened calm, and lines of soundings were rapidly run around the shoal on the sides where no soundings had previously been taken. By noon a fresh breeze had sprung up from the northwest, and the lines of soundings were put further apart, in order that the necessary area might be covered. By 3 o'clock there was too much sea to continue the work, and the required area having been fairly well covered, the party retured to the shore and left for Detroit shortly afterwards, where they were disbanded.

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METHODS.

Shore work.—At Colchester and Pointe Pelée, the shore work was done with Buff & Berger transit No. 245, and some stadias which had previously been constructed for this instrument. These stadias had been used during February and March, 1892, in a survey of the river front at Detroit, and in that survey checks had been taken on the stadia scale in the following manner: At every stadia station, angles had been read to various prominent landmarks and the notes of the survey had been plotted on a scale of 300 feet=1 inch. Where the same landmark—a steeple or light-house, for example—was sighted at from fifteen to twenty stadia stations, if there was no error in any of the distances, in azimuth, or in plotting, the lines from all these stations to the landmark would when plotted intersect in one point. In this way these various landmarks served as a check on azimuths and in a comparative manner on distances. They offered, however, no absolute check on distances, as all the distances might be too large or all to small should the stadia scale be out of proportion. To obtain an absolute check on distances, two lines were taken; the first, the line from Windmill Point light-house to Belle Isle light-house, which had been included in a triangulation made by Col. H. Kallman, U. S. assistant engineer, in January, 1890, from a base line 5,000 feet in length, measured with a 300-foot steel tape on Isle Au Pêche. This triangulation made the calculated length of the line joining the two lights 10,522.7 feet. After the field notes of the Detroit River front survey had been plotted and the two light-houses in question established by intersections, in the manner above indicated, the distance between them was measured with a scale, by an experienced draftsman, who was ignorant of the calculated distance obtained from the triangulation and who made the distance between the two lights 10,522 feet. The second check was made in a similar manner between two triangulation stations of the lake survey in the city of Detroit, "City Hall," and "Swayne." The distance between these stations computed from the records of the lake survey is 12,273 feet. The distance measured on the map by the draftsman when ignorant of the computed distance was 12,273 feet. It was thought, therefore, that a stadia scale which would come as close as this on a scale of 300 feet=1 inch, or 1:3,600 would be sufficiently accurate for the location of shoals upon a chart with a scale of 1:80,000. Nothing but the stadia was used, therefore, in measuring distances.

The manner of measuring the base line for the location of the shoals was as follows: Three observing stations were selected, the middle one about half way between the other two, all three being intervisible, and flagpoles were erected at all of them. The stadia line was then run, each of the three observing stations being occupied in due course by the instrument. From every stadia station angles were read to all three of the observing stations and also to any prominent landmark, such as steeples or light-houses, that might be conveniently situated, and the topography was put in with the stadias at the same time. In this manner a direct check was obtained in azimuth, and an error in any of the distances could readily be detected. To calculate the distance between any two of the observing stations a number of methods could be employed; the simplest and probably the best being the projection of each of the lines between stadia stations upon the line connecting the two observing stations under consideration, and the summing of the projected distances to obtain the required distance. By measuring the base in this manner both money and time were saved; and, although the first was desirable, the latter was essential, for the party barely managed to complete their work by the end of the fiscal year, and it is doubtful if they would have done so had it been necessary to measure a base line with a chain or tape, and then triangulate to obtain suitable observing stations.

In order to locate the hydrographic work upon the map, angles were read from each of the three observing stations to buoys anchored in the lake. In this way three intersections were obtained at each buoy and the chances of error were largely reduced.

At Colchester and Pointe Pelée observations on Polaris at eastern elongation were taken to establish the true meridian, an azimuth being taken in each case to a distant light-house.

Water gauges.—A water gauge was established on the dock at Colchester on May 21, and readings were taken three times daily at 6 a. m., 12 m., and 6 p. m. until June 30. At Pointe Pelée, there being no dock at which a water gauge could be fastened upon the suggestion of Recorder Kallman, a hole was dug in the beach about 15 feet back from the shore line until water appeared; a barrel, open at both ends, was then sunk in this hole and the sand excavated from inside it until the barrel was down as far as it was practicable to drive it. A stake was then driven inside the barrel and close to it and the water guage fastened to this stake. Another and slightly larger barrel was then telescoped firmly over the first one, and the sand filled in outside. In this manner a well was formed in which the water lever was the same as that of the lake outside and fluctuated with it, but was totally unaffected

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by the motion of the waves. This gauge could always be approached and could be read to a fractional part of an inch in the roughest weather. From May 25 to June 30, this gauge was read three times daily, and each gauge was read hourly during times of sounding on the shoal to which it related.

After the return of the party to Detroit, comparisons were made between the two gauges and the one at Cleveland, Ohio, and it was found that the zero of the Colchester gauge was 1.99 feet below high water of 1838 and 0.35 foot above the water surface shown on the chart (mean level of Lake Erie 1860–75), while the zero of Pointe Pelée gauge was 1.24 feet below high water of 1838, and 1.10 feet above the water surface shown on the chart. Expressed as elevations above mean tide at New York City, the different levels are as follows:

High water of 1838, 575.20 feet above mean tide; Pointe Pelée, zero, 573.96 feet above mean tide; Colchester, zero, 573.21 feet above mean tide; water surface of chart (mean level of Lake Erie 1860–'75), 572.86 feet above mean tide.

Temporary bench marks were also established near each gauge for use in case the gauge should be displaced. At Colchester the bench mark was the top of a large bowlder in the gully at the foot of Dunn street and was 5.33 feet above zero of gauge. At Pointe Pelée, the bench mark was the top of a nail driven in the root of an ash tree at the edge of the woods abreast of the gauge and was 4.10 feet above the zero mark.

Hydrographic work.—The object of the surveys being the reëxamination of certain localities where vessels had struck while drawing less water than was shown on the chart, it was of the greatest importance to obtain the minimum depth of water at each place. In order to do this it became necessary to employ the device known as the sweeping bar. As used on this survey, it consisted of a 2¼-inch gas pipe, 27 feet in length, held horizontally below the surface of the water by two small ropes bound to the bar about 8 or 9 feet from either end and passing up to the top of the water; each rope then passed over a pulley and was belayed to a stout beam that lay across the deck of the steamer just forward of the pilot house, the pulleys over which the rope passed being held in the ends of the beam where they overhung the sides of the boat. Both supporting ropes were so marked that the bar could be held horizontally and its depth below the water surface could be gauged according to the depth at which obstructions were looked for. With this device it was necessary for the steamer to move very slowly in order that the bar might hang vertically downward and not swing back and up, as would be the case were the steamer to move at a normal speed. Had the supports of the bar been made rigid—of vertical pieces of gas pipe, for example—so that the steamer could move rapidly, the first time an obstruction was struck the apparatus would have been so badly broken or injured as to cause great delay for repairs. On the other hand, should the bar swing back slightly and rise a foot, or even 2 feet, it was of no particular consequence, as the main use of the bar was as a finder, the steamer being backed and stopped whenever the bar struck, and the obstruction searched for with a sounding pole. Should the obstruction not be found in this manner, as was sometimes the case, then the bar was raised a foot and the steamer started forward very slowly. If the bar struck again it was raised another foot and the same process repeated until the bar passed over the obstruction, when it was lowered to its former depth and the survey continued. In order to tell when the bar struck, a man was stationed at each of the ropes that supported the bar, and kept his hand always in contact with the rope. A spare bar was always carried, in order to minimize delay in case of accident.

It was on account of the slow speed required of the steamer in carrying the bar or sweeping that the *Scotia* was so much better suited to the work than the *C. W. Wells*. The *Scotia* had a double engine, and could run as slowly as desired, whereas the *Wells*, having a single engine, would center if she attempted to go as slowly as was necessary for sweeping. The *Scotia* also was much smaller and lighter than the other boat, and could stop more quickly and was not so likely to run away from an obstruction that the bar had found,

Sweeping being the essential part of the survey, it became necessary to subordinate every other part of the work to this. In order to locate obstructions found by the bar the following method was adopted: Four buoys were anchored approximately in a parallelogram, two of the four sides of which were about 1,000 feet in length; these buoys being located instrumentally from the shore. A line 1,000 feet in length was then anchored along one of the 1,000-foot sides of the parallelogram and a similar line was anchored parallel to the first and 300 feet from it. These thousand-foot lines had every 50 feet marked upon them by a cork, which, floating on the water, could be seen from the adjacent boats. A small boat containing the sounding party would be rowed along one of these cork lines and soundings taken at each of the corks; the boat would then return on a line 50 feet from the first, the position of this line being estimated with sufficient accuracy from the cork lines on either side of the boat, and soundings would be taken abreast of each of the corks. In this manner the area of 300 feet by 1,000 feet would be covered with soundings 50 feet

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apart. The steamer carrying the sweeping bar would follow the sounding boat, first covering the 25 feet next to the cork line, then the 25 feet next to this, and so on, making two runs to every one of the sounding boat. As the bar was 27 feet long there would be a slight overlapping were the steamer to keep a true course each time; should she vary slightly from her course, however, an obstruction would have to be very small to escape her, and by having the bar at a sufficient depth the chance of missing the shallow spots was practically avoided. The sounding boat, completing the given area before the steamer, would proceed to reel up the cork line first placed in position, and would then place it on the other side of the second cork line, parallel to it and 300 feet from it, thus inclosing a new area, which was surveyed in a similar manner to the first one. By this method an obstruction found by the sweeping bar could at once be located within a few feet of its position with respect to the soundings and the buoys. After the shoal proper had been surveyed such lines of soundings would be run as would suffice to develop the bottom in its vicinity. At Colchester quadrilaterals about a mile in length and 2,000 feet in width were sounded as follows: Three buoys were established in line, the middle one being about 1,000 feet from the other two. Three other buoys were established in the same way abreast of the first three, about a mile from them. All buoys were then located from the shore. One-half of this quadrilateral being 1,000 feet by about a mile in area would be surveyed by placing one of the 1,000-foot cork lines between two of the buoys and the other cork line between the two buoys opposite them. A small boat would then anchor at each of the two buoys which marked one of the long sides of this quadrilateral and the steamer would run between the small boats, being kept in range by flag signals from one of the boats. The steamer would run at a uniform speed, soundings would be taken from her on time and on important lines the sweeping bar would be carried very deep to ascertain whether or not any obstruction existed. After the line between the two buoys had been sounded in this manner the small boats would move opposite corresponding corks 200 feet or 300 feet or any desired distance from the buoys and the line between the two boats sounded as before. After the first half of the quadrilateral was surveyed in this manner, the cork lines were shifted to the corresponding buoys in the second half, and the survey was continued. This method was very flexible. With the limited time at the disposal of the party when it became necessary to hurry the work on account of threatening weather the lines of soundings could be placed farther apart, while, should closer examination of any special area prove necessary, the lines could be put closer together, the sounding party being entirely independent of the shore. Had any obstruction been found during the course of this work it was proposed to drop a buoy upon it, finish the line upon which the soundings were being made, and subsequently return to the spot that had been buoyed, and make a special survey of it in a similar manner to that employed on the shoal proper. As no obstruction was found during this work no special survey of this kind was required.

During the progress of the hydrographic work the gauge was read every hour, and the times of beginning and ending of each line of soundings were recorded. Every night after the return of the party to shore, all the soundings were reduced to zero of gauge and were then plotted upon the map at the first practicable opportunity.

RESULTS.

Shoal 3 miles north and west of Pelée Spit light-house.—The first place surveyed in this vicinity was the shoal upon which 3¼ fathoms are shown upon the chart. This shoal was found to consist mainly of a ledge of solid rock, and the least depth found was 18.7 feet, as referred to the water surface of the chart, an area of about 1,430,000 square feet having been passed over by the sweeping bar.

During the past spring Capt. W. A. Grubb, the keeper of Pelée Spit light-house, noticed some ice remaining near this shoal after all the ice had disappeared elsewhere. He had the forethought to establish ranges on the shore in line with this ice, and after the survey of the above-mentioned shoal was finished one of Capt. Grubb's ranges was followed out and a large shoal was discovered about half a mile to the northeast of the first one, where good water is shown on the chart. This shoal was surveyed and three points of minimum depth were discovered, one having 16.1 feet of water on it as reduced to the water surface of the chart, over a ledge of rock; another 13.5 feet over an old wreck laden with iron ore, said to be the *Nicholls*, sunk in 1879 after the former survey was finished, and the third 13.5 feet over a cluster of bowlders. On this shoal an area of 1,100,000 square feet was covered by the sweeping bar. Lines of soundings were run connecting the two shoals, and good water was found between them.

Had it not been for the ranges established by Capt. Grubb it is doubtful if the party would have discovered the new shoal in this locality. They certainly would not have done so without a great loss of time. It is important that as dangerous a shoal as this, so close to the track of vessels, should have a name so that it would

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quickly catch the eye of anyone using the chart. Capt. Grubb's assistance having been entirely voluntary, and having been of great use to the survey, I have therefore to suggest the name of "Grubb Reef" for the two shoals at this point.

The importance of having all dangerous shoals like this one plotted upon the chart at the earliest possible moment is shown by the fact that a vessel is reported to have grounded upon the new shoal at this point shortly after the survey party left Pointe Pelée. She is reported to have struck the spot where the wreck of the *Nicholls* lies, and to have been delayed six or seven hours before being able to lighter off. A wrecking outfit was telegraphed for to Amherstburg and arrived shortly after the vessel had left the shoal. All the expense thus incurred would doubtless have been saved had the shoal been marked upon the chart.

Shoal making out from Littles Point, Lake Erie.—At this locality a shoal was marked upon the chart 1 mile south of Colchester Dock, with a least depth of 16.5 feet upon it. A new shoal was reported three-eighths of a mile south of this one, and was said to be quite extensive and to consist of large bowlders. No sign of this latter shoal was discovered by the survey party, but the shoal shown on the chart was found to be more extensive than there indicated, and to consist of sand, clay, and mud, in which are embedded a large number of bowlders, some of which stand as high as 6 feet above the bottom. The least water was found 1 mile south of Colchester Dock, and is 12.35 feet as reduced to the water surface of the chart. An area of 4,500,000 square feet was swept with a sweeping bar, and the usefulness of this device was fully demonstrated, as the sounding poles and lead lines would invariably give from 4 to 6 feet more water than was found by the bar.

After the shoal had been surveyed lines of soundings were run all around it, and about 2 square miles of area covered. South of the shoal, where a new shoal was reported, lines were run 200 and 300 feet apart from the shoal to the south side of the track of vessels. On these lines the sweeping bar was carried at a depth of 27 feet below the surface and did not strike; thereby demonstrating that no such shoal as was reported was in existence. Whoever located it was doubtless on the shoal marked on the chart, and overestimated his distance from the shore. As it would be well for this shoal to have a name, I have to suggest that it be called "Grecian Shoal," from the name of the vessel that struck upon it in July, 1891.

ESTIMATES AND COST.

The estimate for the survey of the shoal off Pointe Pelée was $1,000. The cost of the work was $553.09. The estimate for the survey of the shoal off Littles Point was $610. The cost of the work was $587.59. Total estimate, $1,610; total cost, $1,140.68.

The party was very much delayed by bad weather. Had the month of June been no more stormy than it ordinarily is, the work would have been finished in a week and a half to two weeks' less time, and the cost would have been proportionately reduced.

In conclusion, I desire to state that Recorder Herman Kallman, jr., who had personal charge of all the offshore work, proved himself highly energetic and efficient, and it was largely due to his efforts that the party were enabled to complete their work before the close of the fiscal year.

Respectfully submitted.

CHARLES S. RICHÉ,
First Lieutenant, Corps of Engineers, U. S. Army.

Col. O. M. POE,
Corps of Engineers, U. S. Army.

B.

REPORT OF MR. E. S. WHEELER, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Sault Ste. Marie, Mich., July 5, 1892.

COLONEL: I have the honor to submit the following report upon the operations connected with the survey of the Northern and Northwestern Lakes, St. Marys River, for the fiscal year ending June 30, 1892:

I received your orders in February to begin a survey of St. Marys River. This survey to be of sufficient accuracy to make a chart in general, similar to the lake survey charts with the hydrography of the channels of about the same accuracy as the usual harbor surveys.

The following surveys which have already been made were to be utalized as far as possible:

(1). United States lake survey made in 1853 and 1854. The shore line and hydrog-

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raphy of this survey to be used excepting where improvements have been or will be made.

(2). Survey made under the direction of Gen. Weitzel in 1879; this is a survey of the channel only.

(3). Precise levels which have been brought from sea level to Lake Superior at Marquette by the United States Lake Survey.

The work required under your orders was as follows:

(1). A primary triangulation connecting the Lake Survey triangulation in the east end of Lake Superior with that in the north end of Lake Huron, with the necessary base lines and azimuth determinations.

(2). Minute hydrography of those points in the channel which have been dredged or otherwise changed since the previous surveys.

(3). Topography of that portion of both banks of the river which is conspicuous from the decks of vessels passing through the river.

(4). The determination of the latitude, longitude, and azimuth of at least one point in the triangulation.

(5). Carrying precise levels westward as far as Bay Mills, for the purpose of making accurate tide-gauge readings at this point.

The actual work of this survey was begun in the last days of May. Assistant Engineer Ripley with a party of about 15 men, the tug *Myra*, and the quarter boat *Swallow* made a minute survey of the shoals at Sailors Encampment.

Mr. Ripley's report is attached herewith:

UNITED STATES ENGINEER OFFICE,
Sault Ste. Marie, Mich., July 4, 1892.

SIR: The limestone shoal at Sailors Encampment was selected for beginning the hydrographic work of resurvey of St. Marys River, Michigan.

Five stations were located for continuing the triangulation of river survey of 1879 from Sailors Encampment to head of Mud Lake.

Each station was marked with a piece of limestone about 1 foot square in which was drilled a hole one-half inch in diameter and 3 inches deep. The stones were placed 3 feet under ground and a wooden tripod built and placed in position over each stone.

The angles were read with the Piston & Martin theodolite, and each triangle closed within three seconds. The present steamboat channel is on the Canadian side and has three courses from angle above shoal to the can buoy in Mud Lake. A channel was selected on the American side of the river with only one course, and the improvements required will be out of the way of passing boats.

Soundings were taken 10 feet apart over an area 400 feet wide and 3,120 feet long, also 30 by 200 feet apart for the full width of the river for a distance of 3,000 feet.

Very respectfully, your obedient servant,

JOSEPH RIPLEY,
Assistant Engineer.

Mr. E. S. WHEELER,
Assistant Engineer, etc.

Assistant Engineer O. B. Wheeler, of the Missouri River Commission, was directed by you to begin the triangulation. Mr. Wheeler reported on the 21st of May, 1892, with 4 assistants from the Missouri River Commission; selected a base line 2 miles in length on Portage avenue. This was measured four times with satisfactory results; he also planned six stations of the triangulation and measured the angles at four of them. Azimuth was observed from a station about 1 mile from the base. Two of Mr. Wheeler's assistants carried a line of precise levels from the masonry of the lock walls to Bay Mills.

Mr. Wheeler's report is attached herewith:

UNITED STATES ENGINEER OFFICE,
Sault Ste. Marie, Mich., June 28, 1892.

SIR: Agreeably to the following instructions I reported at your office, at this place, on May 21, 1892.

DETROIT, MICH., *May 9, 1892.*

SIR: As soon as relieved from duty on the Missouri River Commission, for temporary service in connection with the resurvey of St. Marys River, Mich., you will proceed to Sault Ste. Marie, Mich., and report for duty to Mr. E. S. Wheeler, assistant engineer in local charge of the public works at that place. The travel indicated is necessary for the public service.

Very respectfully,

O. M. POE,
Colonel Corps of Engineers, Bvt. Brig. Gen., U. S. Army.

Mr. O. B. WHEELER,
Assistant Engineer.

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BASE LINE.

The first work was the selection of ground suitable for the measurement of a 2-mile base line, to be measured with the steel tape by night. The location of this base line was finally on Portage avenue, in this city, and extended from Bingham street nearly to the Little Rapids lining, for the most part of the way, through the center of the street-car track, which track was not then in use. The staking out and measuring of the line was identical with the method used in 1885 under the Missouri River Commission and fully reported in reports for 1885–'87. The same "adjuster" as there used was used here, and a standard tape and thermometers belonging to the Commission, together with a standard thermometer 21 inches in length, belonging to Mr. E. S. Wheeler, were used. Three complete measurements were made on the same date (namely, June 1), the first and last measurements agreeing within one-tenth of an inch, the middle one differing by less than one-half inch from either of the others. A 500-foot steel tape, belonging to the office here, was standardized by measuring a commensurate distance of 1,500 feet measured also with the 300-foot standard tape. A copy of the adjuster and reel of the Commission was made for use with the 500-foot tape.

TRIANGULATION STATIONS.

The stations of the base line were so located that the triangulation could be carried off on either side of it. The first station off the base was upon the Ashmun street hill, 1¼ miles from the west base station, and it was selected also as the azimuth station, while the marks (or lantern) was on station "west base." The second station off the base was in Canada, 3 miles from west-base station. The four stations mentioned constitute the first quadrilateral. The fifth and sixth stations are on Sugar Island and Rankins Mountain Canada, respectively, and with the third and fourth mentioned constitute the second quadrilateral. The seventh station is on Larks Ridge, a commanding ridge, about 2 miles southwest from New Fort Brady. All seven stations are described in the notebook and are marked, six with the regulation stone 18 by 18 by 4 inches with a brass center bolt, set 3 feet or more under ground, the sixth being on naked rock, with a half-inch hole drilled in the rock, in which hole is cemented a 20-penny spike with head down. This spike stays the foot of a target. The station is on the highest point of rock within a half-mile radius of the station. At five of the stations portable tripods answer the purposes of a station. At the first station in Canada it was necessary to erect a 21-foot tripod with a target platform at 24 feet above the ground, and on Sugar Island a 57-foot tripod with a 60-foot target platform was necessary, to save the extensive cutting of timber. Assistant Engineer Glen C. Balch successfully supervised the construction of the latter station. Both stations were built of peeled round timber and are models of their kind.

PLAN OF TRIANGULATION.

A quadrilateral system with a minimum limit of a 30° angle in triangles used in computation is contemplated. This is to be carried on from an 11-mile line between the sixth and seventh stations in connection with the fifth reaching Gros Cap or Iroquois Point, going above, or a point in Canada back of Lake George, going below, looking over Sugar Island from the seventh station. A point south of Waiska Bay should be selected for good conditioned triangles, going above. Also a point south from here about 12 miles on Sand Hill or Stony Ridge between the Meridian and Mackinac roads, going below. Stations of any great height will be required only on the Michigan side to get above the timber.

AZIMUTH AND ANGLE READING.

The azimuth and angle readings have been made with the Troughton and Simms Theodolite, No. 1, 14-inch limb, fully described in Professional Papers No. 24, Corps of Engineers, U. S. A. Complete azimuth observations on Polaris near and at elongation with the necessary time-star observations have been secured on two nights. These observations were so satisfactory (differing at elongation by only 1.6 seconds) that it was not considered necessary to obtain a third night's observation, especially as the time for angle reading was limited. No star at western elongation was available or it would have been read upon. One half of the observations were from image of the star from an artificial horizon, thus doing away with the reading of the level, a method most highly to be commended. The mark at west base station, was a light through a vertical slit two-tenths of an inch in width. Fogs and clouds cut off the work on many nights. At three of the stations a portable station 6 feet in

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height has been used, and the readings over the base line were made before 6 a. m., before the street cars were in motion.

The reading on first quadrilateral are completed—three of the triangles closing on the first attempt within the primary limit of 3 seconds, the fourth closing outside this limit was reread at one station. The remaining three stations are approximately located. Vertical angles were read at all stations occupied. The readings on angles and azimuth were all made by Assistant Engineer E. B. Wheeler, and recorded by Assistant Engineer Glen C. Balch or myself.

PRECISE LEVELS.

A line of precise levels was run from B. M. "F." of the Ship Canal to the water gauge established at Bay Mills, on a bay which may be considered a part of Lake Superior proper, to find the slope of the St. Marys River above the canal. The report of the assistant engineers who did the work is herewith appended. An approximate result from the few water-gauge readings at Bay Mills indicate a slope of about 0.42 foot.

I desire to commend highly all the assistant engineers who aided me in the work.

Very respectfully,

O. B. WHEELER,
U. S. Assistant Engineer.

Mr. E. S. WHEELER,
U. S. Assistant Engineer.

UNITED STATES ENGINEER OFFICE,
Sault Ste. Marie, Mich., June 27, 1892.

DEAR SIR: Following your instructions a line of precise level was run from B. M. "F" on the northwest corner of the lock to a gauge in Waiska Bay.

The length of the main line was 14 miles and 20 yards. The limit of error allowed was $3^{mm}\sqrt{K}$, where K represents distance in kilometers. The main line was run in seventeen sections. Of the seventeen, eleven checked on first trial, three were run three times, two were run four times, and one was run five times. In two cases only did the error exceed 9^{mm} to the mile on the first trial.

The adjustment of the bubbles on the rods was tested daily. The adjustments for collimation and inclination were tested morning and evening, except in one or two cases where prevented by rain.

The maximum error allowed in collimation was 2^{mm}. The maximum error allowed in inclination was two divisions of the level tube.

Four permanent and seventeen temporary bench marks were established and described in the notebooks.

The zero of gauge in Waiska Bay was found to be 1.1541 meters = 3.78 feet below B. M., "F."

Very respectfully, your obedient servants,

B. J. THOMAS.
A. O. WHEELER.

Mr. O. B. WHEELER,
U. S. Assistant Engineer.

The following instruments for use on this work have been received:

1 Negus chronometer, No. 1524; 2 Troughton & Simms theodolites, Nos. 1 and 3, with 14 inch limbs; 1 Wurdemann zenith telescope, No. 12; 1 Wurdemann transit, No. 1; 1 chronograph, by Bond & Son.

All of these instruments were received in good order, except the zenith telescope, which had evidently been injured in transit.

All work was stopped on the 30th of June. Assistant Engineer Wheeler returned to the Missouri River Commission, taking with him the base-measuring apparatus.

Very respectfully, your obedient servant,

E. S. WHEELER,
Assistant Engineer.

Col. O. M. POE,
Corps of Engineers, U. S. A.

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CCC 2.

SURVEY OF WAVERLY SHOAL, LAKE ERIE.

REPORT OF MAJ. AMOS STICKNEY, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., January 16, 1892.

GENERAL: I have the honor to submit the following report upon the survey of Waverly Shoal, Lake Erie. This shoal takes its name from the fact that the propeller *Waverly* struck upon it September 26, 1890, on voyage from Buffalo, N. Y., to Gladstone, Mich. The vessel was drawing 15 feet of water at the time of striking the shoal, and remained fast until a part of her load was removed, when she got off, reloaded, and proceeded on her way, after a detention of three and a half days. The shoal lies nearly on the line laid out in the Lake Survey chart as the course from Buffalo, N. Y., to Fairport, Ohio. It was not discovered by the Lake Survey, as the adjacent lines of deep-water soundings passed on either side of it. The general direction of the axis of the shoal is northeast and southwest, and it is about $2\frac{1}{4}$ miles from the Buffalo Breakwater light-house, and about $1\frac{5}{8}$ miles from the Canadian shore. The 18-foot contour surrounds an area of about 700 feet in length, by from 100 to 200 feet in width. The 16-foot contour surrounds a space about 160 feet in length by 20 to 50 feet in width. The least depth found was 15 feet, though it is probable that there is less depth over some of the bowlders. A buoy was placed on the shoal by the inspector of the tenth light house district in June, 1891.

The survey was made by Mr. Ernest Siegesmund, assistant engineer, in the latter part of Septembr, 1891, when the weather was fair and the lake calm. Buoys were anchored along the axis of the shoal and their bearings taken with a theodolite from a base-line measured on the shore and from the Horse Shoe Reef light-house, the Buffalo breakwater light-house, and the south end of the breakwater. Light lines were stretched between the buoys and other lines to small boats anchored at various points. By means of these lines the points of soundings were located with sufficient accuracy. Nearly 1,300 soundings were made, covering the area of less than 24 feet depth, and some lines run out to deeper water.

The soundings are reduced to the same plane of reference as those on the chart of the lake survey of 1875.

The bottom is rock, with bowlders upon it.

Two charts* accompany this report, one showing the soundings and the other showing the location of the shoal.

The location, as near as it could be determined, is marked in pencil on the original lake survey chart sent to me from your office.

The shrinkage of the paper makes it difficult to locate any point on this chart with precision.

Very respectfully, your obedient servant,

AMOS STICKNEY,
Major of Engineers, U. S. A.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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*Omitted.

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C C C 3.

SURVEY OF SHOALS IN ST. LAWRENCE RIVER, NEW YORK.

REPORT OF MAJOR MILTON B. ADAMS, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

1. HASKELL SHOAL.

UNITED STATES ENGINEER OFFICE,
Burlington, Vt., October 9, 1891.

GENERAL: I have the honor to report the completion of the survey of the St. Lawrence River near Haskell Shoal made by your instructions of August 10, 1891.

A chart* is transmitted herewith, on which a very dangerous shoal is indicated in red ink, and the least depth on the shoal, 13 feet, is also shown.

Two other shoals were found in the course of the survey of the locality with only 26 feet of water where much greater depths are indicated on the chart; they have also been indicated in red ink on the chart herewith.

The search NNW. of Haskell Shoal only developed the existence of the one shoal there that has 26 feet of water over it, and the search was made so thoroughly that it seems reasonable to assume that there is no other shoal in that part of the river.

The fact that another shoal has been found to exist in the St. Lawrence River almost in exact course of passing steamers, only known to one vessel captain and located by him half a mile below its true position, would seem to emphasize my recommendation of October 10, 1888. (See Report of Chief of Engineers, 1889, page 2463, 1st to 7th lines.)

Again the opinion is advanced that the method of sounding used in the survey of the river for the location of its rocky shoals was not sufficiently searching, and that it might well be supplemented by thoroughly dragging all its navigable portions.

* * * * * * *

Very respectfully, your obedient servant,

M. B. ADAMS,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. F. M. BARSTOW, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Burlington, Vt., November 10, 1891.

SIR: I have the honor to submit the following report on the survey of the mid-channel shoal recently discovered between Cross-over and Sister Island lights, in the St. Lawrence River, New York:

This shoal is not indicated on the sailing charts, and its existence was unknown until a deep-draft vessel recently ran upon it. It is located in a direction S. 26° 30′ W. from Dark Island, N. 80° E. from Cherry Island, and N. 50° W. from Scow Island, about one-fourth of a mile above Haskell Shoal in mid-channel, directly in the usual sailing route of vessels. It is also situated nearly in the same straight line as the three shoals located and described in my report to you dated June 29, 1889, and the reasons given for the removal of those shoals are applicable to this shoal.

*Omitted.

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The idea advanced in that report, that these shoals, being nearly in the same straight line, might be parts of the same ledge, and "that this ledge may come within 18 feet of the surface in other places not now known," seems to have been verified by the finding of this heretofore unknown shoal.

The mid-channel shoal, about one-quarter of a mile below Sister Island, was also surveyed, but its removal does not appear to be as necessary on account of its nearness to a light-house.

* * * * * * *

Very respectfully, your obedient servant,

F. M. BARSTOW,
Assistant Engineer.

Maj. M. B. ADAMS,
Corps of Engineers.

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2. SHOALS NEAR CROSS-OVER LIGHT.

UNITED STATES ENGINEER OFFICE,
Burlington, Vt., July 7, 1892.

GENERAL: In compliance with your indorsement dated January 7, 1892 (file-mark, 187, 1892), a survey has been made of four shoals in the St. Lawrence River near Cross-over Light, by Assistant Engineer F. M. Barstow, under my instructions, and I have the honor to transmit herewith a tracing* from the drawing made of the shoals and his report on the survey.

The bearings for locating the shoals on the river charts were taken from well-defined bench marks, and Cross-over and Coles light-houses were used in this connection before the recent instructions on the subject were received from the Light-House Department. Soundings were made over the shoals to 21-foot depths and their contents calculated, so as to be in readiness to estimate for their removal.

In view of the recent movement towards effecting a depth of 20 feet in the upper lake channels, I have the honor to recommend that the excavations of the shoals in the St. Lawrence River be carried to the same depth that may be authorized by Congress for the upper lakes; *i. e.*, as soon as authorized there, then the excavations in the St. Lawrence River be planed and estimated for the same depth.

* * * * * * *

It is believed that of the several shoals found and sounded * * * Haskell Shoal, the one situated one-fourth of a mile above Haskell Shoal, and the one near Cross-over Light (No. 1), are the most dangerous.

* * * * * * *

Very respectfully, your obedient servant,

M. B. ADAMS,
Major of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. F. M. BARSTOW, ASSISTANT ENGINEER.

CEDAR ISLAND, N. Y., *June 30, 1892.*

SIR: I have the honor to submit the following report on the survey of certain shoals in the St. Lawrence River, New York.

The survey was made to find, locate, and measure four certain shoals reported to you as having been struck by large vessels navigating these waters during the low water of last fall. They will be designated as Nos. 1, 2, 3, and 4.

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* Omitted.

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Shoals Nos. 1 and 2 were found, located, and measured without trouble. Nos. 3 and 4, after most careful and repeated soundings, I am unable to find, but have found two others, Nos. 5 and 6, in the channel that are liable to be struck by large vessels at any time.

Shoal No. 1, from its location between Cross-over Light, Whale-back Shoal, and Bay State Shoal in mid-channel, where the channel is narrow and crooked, is one of the most dangerous shoals in this vicinity. I consider its removal to 18 feet below low-water mark necessary to afford safe navigation for large vessels.

* * * * * * *

Shoals Nos. 2 and 5 are in Canadian waters, near a light-house, where the channel is wide. A buoy placed upon them would appear to be sufficient protection. Shoal No. 6 is near the Bay State Shoal, and on side of the channel, so it seems to me that if a buoy were placed upon it the protection would be ample.

None of the above-described shoals are indicated on the sailing charts now in use. Their exact location, with soundings taken upon them, are included in the map, field book, and more detailed letter accompanying this report.

Very respectfully, your obedient servant,

F. M. BARSTOW,
Assistant Engineer.

Maj. M. B. ADAMS,
Corps of Engineers.

C C C 4.

RESURVEY OF THE LAKE FRONT AT CHICAGO.

REPORT OF CAPTAIN WILLIAM L. MARSHALL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

(For letter of transmittal see Appendix J J.)

An allotment of $2,000 from the appropriation for the fiscal year ending June 30, 1892, was made and assigned by the Chief of Engineers to this office for a resurvey of the obstructions due to rock reefs, lying off shore between Thirty-fifth street and the south limit of Jackson Park, for the correction of existing maps.

A party was organized in April, 1892, and prosecuted work during the remainder of the fiscal year.

A base line was measured on the exterior breakwater and a triangulation carried from Diversey street to Calumet Harbor, fixing the shore line. Six angles of this triangulation remain to be measured.

Forty-three lines of soundings were made south of Thirty-fifth street and 18 lines north of Thirty-fifth street. The rock obstructions have been located, but more detailed examination will be made of them.

The survey will be completed to include the harbors and approaches to Chicago and Calumet harbors, at the expense of the appropriations for these harbors.

No further funds required.

The report of Assistant Engineer L. M. Mann, herewith, shows in detail the work done.

Money statement.

April 6, 1892, amount available per letter Chief of Engineers	$2,000.00
June 30, 1892, amount expended during the fiscal year	1,172.99
July 1, 1892, balance unexpended	827.01
July 1, 1892, balance available	827.01

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REPORT OF MR. L. M. MANN, ASSISTANT ENGINEER.

CHICAGO, ILL., *June 30, 1892.*

CAPTAIN: I have the honor to report the work done on the survey of the lake front, Chicago, during the fiscal year ending June 30, 1892.

After a few days spent in preparing tools, instruments, etc., and putting steam launch in good condition, actual work in the field was commenced April 25.

A base line was measured on the exterior breakwater with a 100-foot steel tape with spring balance attachment. Four measurements resulted in a mean of 5,407.87 feet. Starting from this base a triangulation system was established covering the shore line from Diversey street (north end of Lincoln Park) to Calumet Harbor (South Chicago). The unusual advantage of the three lake cribs and the Auditorium tower as triangulation stations enabled me to evolve a very good system. All points south of the Auditorium to South Chicago form independent triangles with the 4-mile crib and the tower. There are thirty-four triangles in the system, requiring observation of one hundred and two angles. One of the sides, CC′, on the easterly breakwater was subsequently measured, making a second base line. Also connections were obtained with the city base line, giving three measured bases in the system. The angles were observed with a transit reading to thirty seconds; four repetitions for each angle were read. Two-thirds of the triangles were closed within four seconds.

Total number of angles observed = 161 sets; in some cases more than one set was read to close triangle within limits.

Total number of azimuths = 192.

The triangulation is very nearly complete; six angles are still required to close four triangles.

The stadia work, which covers about 16 miles of shore line, is complete. All piers, slips, jetties, revetment, etc., along the shore were located; also prominent streets, buildings, etc. Total number of stadia readings = 1,813.

Twenty sounding stations were located from Chicago Harbor to Twelfth street, 400 feet apart; and from Twelfth to Seventy-first street 171 sounding stations were located, 200 feet apart.

Forty-three lines of soundings were run in lake south of Thirty-fifth street, some of them extending 2 miles from shore.

Eleven lines were run east of easterly breakwater to 25 feet of water.

Seven lines were run in Outer Harbor.

Total number of soundings = 7,833; total number of sounding angles = 2,858.

A preliminary examination of rocky reefs off Forty-seventh street and between Fifty-sixth and Fifty-eighth streets shows that a very close location of same is essential.

Inner reef at Forty-seventh street is about three-fourths of a mile from shore; least sounding taken over same was 3.9 feet at datum.

Outer reef at Forty-seventh street is about 2 miles from shore; least sounding taken, 20 feet at datum; but probably there is shoaler water.

Outer reef at Fifty-sixth street is about 1¼ miles from shore; least sounding taken, 11.6 feet at datum.

Inner reef about 1¼ miles from shore; least sounding taken, 9–10 feet at datum.

There is over 30 feet of water between these reefs, and also inside of inner reef.

Both the months of May and June have been about the rainiest months on record; the extraordinary bad weather has delayed the work to an unusual degree.

Very respectfully, your obedient servant,

L. M. MANN,
Assistant Engineer.

Capt. W. L. MARSHALL,
Corps of Engineers, U. S. A.

C C C 5.

SURVEY OF BLACK CREEK SHOAL, LAKE ONTARIO.

REPORT OF CAPTAIN DAN C. KINGMAN, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

UNITED STATES ENGINEER OFFICE,
Oswego N. Y., October 28, 1891.

GENERAL: I have the honor to transmit herewith a copy of the report of Assistant Engineer Judson upon an obstruction to navigation which was said to exist in Lake Ontario at a point about 4 miles west of Little Sodus Light, and about 1 mile out from the shore.

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It will be seen from his report that such an obstruction does exist, but it is of less importance than I was led to believe, because it is only about one-third of a mile from the shore, where the chart calls for 12 feet of water, instead of 1 mile from the shore, where the chart shows a much greater depth.

It can hardly be regarded as an obstruction to large vessels, though it might be dangerous to small ones.

The original lake survey sheet* is mailed to you to-day in a separate package.

* * * * * * *

I have the honor to be, very respectfully, your obedient servant,

DAN C. KINGMAN,
Captain of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

REPORT OF MR. WILLIAM PIERSON JUDSON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., October 27, 1891.

SIR: I have the honor to report that, in compliance with your orders to find, and make a survey of unlocated rocks said to lie in Lake Ontario about 4 miles west of Little Sodus, I left Oswego on the night of October 2 with the steamer *Hasleton* (which had been hired at $10 per working day or $5 per idle day), ran in to Little Sodus for the night, and, on the morning of the 3d found the shoal in question, with the aid of George Carter, a fisherman, whose partner had reported its existence.

The main rock in the shoal has 4 feet depth at present stage of water level (1 foot above extreme low water), and lies one-third mile off the Black Creek outlet, where the lake survey chart shows 12 feet depth.

Conspicuous landmarks were identified on the original detail sheet of the lake survey, and a base line was located on the beach by triangulation from these landmarks. From this base line buoys on the shoal were located, checked by sextant angles taken at the buoys. Five deeper rocks near the main and largest one were also located, and the vicinity for one-half mile radius was closely examined to obtain assurance that no shoal spots were overlooked. The only rocks to be noted were five, which were found within 200 feet of the shoalest and largest one.

The details are fully given upon the maps* herewith submitted.

* * * * * * *

I am, very respectfully, your obedient servant,

WM. PIERSON JUDSON,
Assistant Engineer.

Capt. DAN C. KINGMAN,
Corps of Engineers.

C C C 6.

ANNUAL WATER-LEVEL CURVES OF THE NORTHERN AND NORTHWESTERN LAKES.

Tridaily observations were made at Charlotte, N. Y., on Lake Ontario, from July, 1887, to June 30, 1892, and at Oswego, N. Y., from July, 1890, to June 30, 1892. Observations were also made at Cleveland Harbor, Ohio, and at Erie Harbor, Pa., on Lake Erie, from July, 1887, to June 30, 1892; at Milwaukee, Wis., on Lake Michigan, from July, 1887, to June 30, 1892, and daily observations at Escanaba, Mich., on Green Bay, from July, 1887, to June 30, 1892. At the last-named place observations were not made in January, February, March, and

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*Omitted.

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April of 1888, nor in January, February, and March of the years 1889, 1890, 1891, and 1892, by reason of ice and snow.

Daily observations were made at Sand Beach, Mich., on Lake Huron, and at Sault Ste. Marie and Marquette, Mich., on Lake Superior, from July, 1887, to June 30, 1892.

The accompanying tables and plates are continuations of those published in the Annual Report of the Chief of Engineers for 1887, Part III, page 2418.

Monthly mean of water levels for the several stations below the planes of reference adopted in 1876. (See plates).

Stations.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.
	1887.							1888.					
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Charlotte	......	1.34	1.83	2.43	2.91	3.40	3.55	3.67	3.86	3.64	3.14	2.98	2.88
Erie	......	1.42	1.90	2.14	2.37	2.75	2.74	2.84	3.33	3.24	2.58	2.41	2.11
Cleveland	......	1.27	1.59	1.82	2.41	2.68	2.66	2.84	3.11	3.01	2.38	2.13	2.00
Milwaukee	......	1.92	2.06	2.40	2.85	3.18	3.30	3.48	3.53	3.85	3.14	2.76	2.49
Escanaba	......	2.07	2.33	2.63	3.00	3.16	3.78	......	......	......	......	2.97	2.77
Sand Beach	......	1.88	2.09	2.44	2.66	3.11	3.40	3.51	3.60	3.43	3.29	2.85	2.55
Marquette	......	3.07	2.99	3.18	3.20	3.44	3.65	3.77	3.75	3.83	3.83	3.36	2.57
Sault Ste. Marie	3.317	2.947	3.064	3.005	3.031	3.260	3.665	3.815	4.166	4.115	4.125	3.524	2.675
	1888.							1889.					
Charlotte	......	2.95	3.11	3.34	3.68	3.81	3.85	3.73	3.43	3.36	3.19	2.94	2.50
Erie	......	1.90	1.97	2.38	2.60	2.60	2.60	2.67	2.81	3.12	2.79	2.66	2.13
Cleveland	......	1.85	1.95	2.39	2.76	2.70	2.82	2.80	2.96	3.12	2.77	2.59	2.16
Milwaukee	......	2.48	2.60	2.75	3.00	3.05	3.63	3.65	3.68	3.70	3.69	3.61	3.15
Escanaba	......	2.66	2.77	2.93	3.18	3.45	3.80	......	......	......	4.04	3.98	3.55
Sand Beach	......	2.52	2.48	2.78	3.07	3.25	3.46	3.60	3.68	3.70	3.77	3.63	3.30
Marquette	......	2.38	2.25	2.30	2.39	2.52	2.88	3.34	3.40	3.58	3.40	3.22	3.09
Sault Ste. Marie	......	2.518	2.523	2.604	2.620	2.819	3.158	3.432	3.722	3.700	3.705	3.144	2.965
	1889.							1890.					
Charlotte	......	2.36	2.61	3.15	3.47	3.80	3.58	2.97	2.66	2.67	2.13	1.75	1.18
Erie	......	2.04	2.35	2.69	3.16	3.18	2.93	2.33	2.30	2.10	1.86	1.46	1.17
Cleveland	......	1.96	2.27	2.66	3.08	3.35	3.09	2.73	2.44	2.32	1.83	1.49	1.12
Milwaukee	......	2.97	3.21	3.38	3.63	3.98	4.16	4.08	4.12	4.14	3.82	3.59	3.18
Escanaba	......	3.28	3.42	3.59	4.13	4.42	4.49	......	......	......	4.23	3.07	3.54
Sand Beach	......	3.04	3.10	3.27	3.64	3.98	4.14	4.07	4.19	4.21	4.07	3.76	3.33
Marquette	......	2.90	2.72	2.59	2.75	3.06	3.36	3.49	3.63	3.87	3.89	3.69	3.23
Sault Ste. Marie	......	2.697	2.690	2.607	2.844	3.143	3.531	3.476	4.030	4.037	4.103	3.640	3.029
	1890.							1891.					
Charlotte	......	1.23	1.80	2.27	2.50	2.55	2.78	3.10	3.02	2.43	1.86	1.93	2.34
Oswego	......	1.06	1.78	2.14	2.46	2.38	2.62	2.91	2.66	2.12	1.61	1.86	2.27
Erie	......	1.55	2.01	2.31	2.37	2.23	2.40	2.78	2.72	2.48	2.51	2.70	2.56
Cleveland	......	1.50	1.94	2.13	2.32	2.35	2.58	2.80	2.82	2.36	2.49	2.67	2.53
Milwaukee	......	3.11	3.19	3.39	3.50	3.84	4.19	4.21	4.45	4.26	3.95	3.85	3.70
Escanaba	......	3.44	3.55	3.65	3.89	4.36	4.53	......	......	......	4.38	4.22	4.19
Sand Beach	......	3.14	3.14	3.41	3.62	3.82	4.12	4.32	4.43	4.46	4.13	3.89	3.94
Marquette	......	2.94	2.73	2.66	2.69	2.90	3.26	3.63	3.76	3.80	3.84	3.64	3.58
Sault Ste. Marie	......	2.695	2.786	2.897	2.641	3.104	3.408	4.008	3.987	4.133	3.959	3.529	3.580
	1891.							1892.					
Charlotte	......	2.65	3.02	3.44	4.07	4.77	4.76	4.55	4.62	4.64	4.22	3.98	3.40
Oswego	......	2.55	2.99	3.42	4.06	4.66	4.69	4.59	4.62	4.49	3.92	3.85	3.29
Erie	......	2.56	2.85	3.06	3.39	3.60	3.48	3.43	3.97	3.80	3.36	2.56	1.84
Cleveland	......	2.63	2.90	3.08	3.46	3.90	3.83	3.80	4.01	3.97	3.41	2.61	1.85
Milwaukee	......	3.871	3.936	4.170	4.531	4.926	4.986	4.874	4.676	4.777	4.716	4.297	3.854
Escanaba	......	4.269	4.430	4.515	4.796	5.220	5.280	......	......	......	5.200	4.917	4.450
Sand Beach	......	3.91	4.01	4.20	4.57	4.88	4.94	4.92	4.98	4.92	4.84	4.71	4.18
Marquette	......	3.39	3.228	3.231	3.074	3.37[illegible]	3.90	3.90	4.18	4.31	4.30	3.97	3.59
Sault Ste. Marie	......	3.468	3.456	3.522	3.466	3.575	3.840	3.945	4.303	4.483	4.331	3.820	3.460

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The following corrections are to be made in the monthly mean of water levels for Lake Erie below the plane of reference adopted in 1876, as given in the Annual Report of the Chief of Engineers for 1887, Part III, page 2418:

	1886.							1887.					
		July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.
Erie	......	1.47	1.66	1.89	2.07	2.11	2.24	2.43	1.85	1.49	1.51	1.30	1.20
Cleveland	......	1.22	1.43	1.67	1.90	2.31	2.26	2.49	2.07	1.26	1.24	1.06	1.03

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APPENDIX D D D.

CONSTRUCTION AND IMPROVEMENT OF ROADS AND BRIDGES IN THE YELLOWSTONE NATIONAL PARK.

REPORT OF MAJOR WILLIAM A. JONES, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minn., July 1, 1892.

GENERAL: I have the honor to submit herewith my report of operations for the improvement of Yellowstone National Park during the fiscal year ending June 30, 1892.

Very respectfully, your obedient servant,

W. A. JONES,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

The project for this work was adopted in 1883, when the control was placed in the hands of officers of the Corps of Engineers, and consists in the construction and maintenance of about 225 miles of road, with the necessary bridges, culverts, etc. The roads embraced in the project commence at Gardiner, at the north boundary line of the park, thence to Mammoth Hot Springs; thence to Upper Geyser Basin, passing through Norris Geyser and Lower Geyser basins; thence to the outlet of Yellowstone Lake via Shoshone Lake and the west arm of Yellowstone Lake, crossing the Continental Divide of the Rocky Mountains twice; thence to Yanceys, via the Falls and Grand Canyon of the Yellowstone River; thence to Mammoth Hot Springs, completing the so-called belt road, with a circuit of about 145 miles. In addition there are projected: A road from the west boundary line of the park, passing through Lower Geyser Basin, and continued easterly to intersect the road along the Yellowstone River to the falls; a road from Norris Geyser Basin to the Falls of the Yellowstone; a road from Yanceys to the east bounday line of the park, and a number of short branch roads and trails from the above-named roads to objects of interest off the main line of travel; in all, 225 miles of new road,

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about 20 large and 50 small bridges, with many culverts, etc. Estimated cost, as revised in 1889 by my predecessor, $444,779.42.

The act of Congress approved March 3, 1891, changed the project of the part of the belt line between Lower Geyser Basin and Yellowstone Lake by requiring the road to be built "by the shortest practicable route" from Fountain Geyser to the thumb of the Yellowstone Lake. This change did not materially affect the cost.

At the beginning of the year the roads that were open to travel were:

Completed roads.—(1) The road from Gardiner to Mammoth Hot Springs, Norris, Lower and Upper Geyser basins completed, except a projected stretch of 8.9 miles of new road in Gibbon Canyon, designed to replace an equal length of the old road and some minor changes in the location of different parts of the road. (2) The road from Norris Geyser Basin to the Falls of the Yellowstone.

Uncompleted roads.—(1) The road from Upper Geyser Basin to the Falls of the Yellowstone via Yellowstone Lake and outlet, except two short sections. (2) The two roads known as the Madison Canyon road and Howard trail, from the western boundary line of the Park to Lower Geyser Basin, where they joined, and their continuation as one road to the uncompleted road from Yellowstone Lake outlet to the falls. (3) The road from Mammoth Hot Springs to Yanceys and its continuation to eastern boundary of the Park.

Total amount expended upon the project since commencement of the work, 1883 to June 30, 1891, including outstanding liabilities, $259,779.42.

WORK DONE.

The close of the last fiscal year found the work well under way partly by contract and partly by days' labor. One firm, Wyatt & Scott, were engaged upon their contract, while Mr. A. Z. Partello was, after looking over the ground, about reaching the conclusion to abandon his. The facts before me at this time indicated that he had not the means to execute his contract, and that any effort to force his bondsmen to execute it would only end in delay and probably failure. His bid was altogether too low and had not been based upon any knowledge of the local conditions.

Consequently, when he abandoned the work on the 4th of July, I took advantage of a clause in the contract which enabled me to proceed with his work by days' labor. The possibility of his failure had been fully foreseen and a plan of procedure discussed and adopted to meet it. On account of the magnitude of the work in hand and the extreme shortness of the season within which it could be accomplished, there was not a moment to lose, and four additional parties were immediately organized and placed in the field. Attention is invited to the celerity with which this was accomplished. Four entire outfits of tools, camp equipage, and provisions had to be purchased, and, together with four large crews, placed at work in the wilderness at a distance of from 60 to 80 miles from our base. Two parties were at work on the 16th and the other two on the 19th of July.

With the hope of holding up Mr. Partello in the execution of his contract I sent Mr. W. A. Campbell, an experienced contractor in road work, to look over the ground and engage himself to Partello to supervise and execute the work. An examination of the ground convinced him that the loss on the contract would be so great that he would not be likely to get anything for his services, and he declined to undertake it. Mr. Partello failed to satisfy him that he had any funds for the

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execution of the work. Whereupon, after notifying his bondsmen and trying to get them to undertake the work, I laid the matter before the Chief of Engineers, with the recommendation that the contract be annulled. Under date of August 25, 1891, this recommendation was approved.

TEAM HIRE.

Under date of May 30, 1891, after advertisement in the papers of Minnesota, Montano, and Oregon, I opened bids for furnishing team hire for the season's work in the park. The specifications required that the teams should be furnished, together with a complete contractor's plant for clearing and grading for as many parties as I might wish to place at work. The lowest bid was $5.10 per day for each two-horse team and driver, including the whole plant. This was a reasonable price. No formal bonded contract was entered into, but Mr. A. L. Love, of Livingston, Mont., who made the proposal, carried it out in a very satisfactory manner in the face of many and trying difficulties.

BELT ROAD.

The objective of the season's work was to open what may be called a Belt line passing the principal points of interest and doubling on itself at Norris. This required the completion of about 53 miles of new road lying mostly out of reach of supply roads. In order to supply one of the mountain camps and those on the lake shore water transportation on the lake was necessary, and a steam launch was shipped out from Minnesota for the purpose. After considerable difficulty in getting it from the railroad to the lake, a distance of over 60 miles, it was fitted up and served the purpose admirably. Not only did this effect a great saving in the transportation of supplies, but it was the move which rendered possible the great amount of work done in such a short time. The line constructed crossed the Rocky Mountain divide twice where it involved heavy and difficult work, and then followed the lake and river shore the rest of the distance, crossing all the streams and swamps. The greater part was in a country very densely timbered, with the dead and fallen timber so thickly interlaced upon the ground as to be passable only to pedestrians.

A base of supplies was established at Mammoth Hot Springs, with a secondary base at the outlet of Yellowstone Lake, and after a little friction at starting the crews were very well provided for.

RECORD MAP.

In order to make a record of the work done, as well as that which had been previously done, I gave careful instructions to the assistant engineers on the line of contract work to make such measurements and observations as would enable me to make a good map of the road and the country immediately alongside of it. I regret to say these instructions were only partially executed. The work progressed so rapidly that all of their time was taken up in laying out work for the crews. A special party operated on the line of the completed roads. Here, too, my instructions were not fully carried out, and hence I am unable to present an exact estimate of the cost of placing gravel on the roads, since I have no exact information as to the location of the gravel and the stretches of road which will require it. The results of these measurements are

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embodied in a series of road maps* herewith. The profiles* are in the report of Lieutenant Chittenden. Together they make a good record of the work done up to date, and will form a foundation for all future work. Based on the exact information thus secured, a map of the Park has been prepared. A copy is herewith.

The record shows a few grades and locations which doubtless may be improved, but if we could complete it with the story of small appropriations and the pressing necessities in the early history of this work, for making an opening through the woods and mountains somehow or other, and that very quickly and with insufficient means, the surprise would be that it should have been so well done. In those days it was out of the question to make anything more than common dirt roads. But even as some of our finest modern railroads have been evolved from a beginning of track and bed such as we now laugh at, so will the dirt roads in Yellowstone Park in time evolve a system of beautiful graveled roads.

* * * * * * *

In laying out the new roads I have kept constantly in view the fact that they are to be pleasure roads and not lines of commercial transportation. The best location and grades have been studied in the light of instrumental measurements. Points of view have been sought and an effort made to have each drive a series of pleasant surprises in landscape. The line along Yellowstone Lake and River is one of bewildering beauty. The contrasts are magnificent. I do not hesitate to say that in due time the scenery displayed by these drives will rival the wonders of the Park in its attractiveness.

GRAVEL ROADS.

Good roads are the climax of civilization. It is essential that they have easy grades, that they be well drained, and that the surface be hard and reasonably free from dust. It is more than all essential that they be kept continuously in repair. The surface of a park road need not be so hard as that of a traffic road. In Yellowstone Park during the spring season, when the frost is coming out of the ground, the roads will be but little used. Commencing about the 1st of June, the roads will be used until about the 1st of November of each year, only four months. Obviously, a well-constructed road surfaced with gravel will suffice. After grading, the bed should be hardened as much as possible by rolling, after which a well-rolled layer of gravel should complete it. The ditches should be pitched with stone in steep places and the subway drained by tiles beneath the ditches. These tiles can be made in the Park.

A considerable portion of our roads passes through gravel deposits and will need no further surfacing. The remainder lie within easy reach of an abundant supply of gravel. It is mostly obsidian, or volcanic glass, and makes an excellent road covering. On account of its great specific gravity its dust does not fly sufficiently to create any serious annoyance. It is not likely that after being graveled the Park roads will ever need watering except over a few short stretches. At such places an effort will be made to suppress the dust by sprinkling. I do not think the cost of graveling such portions of the roads as need it will be excessive. It is impossible with the data at hand to make a close estimate, but during the coming season considerable graveling

* Not printed.

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will be done with a view of strengthening the weak places against the traffic of the World's Fair year, and the exact cost will thus be determined practically. I should say that it would cost not less than $500 nor more than $1,000 per mile.

The question of repairs will hereafter be a prominent factor. An average of $100 per mile per year is very much within the experience of those who keep up good roads. This on a length of 200 miles becomes $20,000 per year. But new roads cut through mountains and hilly country will for a few years require excessive expenditures for repairs. There will be many slides to remove and soft places to brace up.

RÉSUMÉ OF SEASON'S WORK.

During the month of July the two Government crews working on the road between Fountain Geyser and Yellowstone Lake had by the end of the month accomplished: At east end 2½ miles of completed road and an additional half mile cleared; on the west end, 9,000 feet completed, and cleared and grubbed 2 miles additional. Work on the road from Grand Canyon to west end of Yellowstone Lake was vigorously pushed all along the line. Contractors Wyatt & Scott, for section 4 (7½ miles in length), have now completed 4 miles. Sections 1, 2, 3, and 5 had been placed under contract with William Z. Partello, but he having failed to commence work, Government crews were organized early in the month and commenced construction; 4 miles were graded and 6 miles were cleared ready for grading. The lumber for all the large bridges on new roads had been sawed and part of it delivered at the bridge sites. The road repair crews completed necessary repairs on Brickyard Hill and commenced work on Canyon Hill. They, besides, kept all the roads in good order during a period of very heavy rainfall.

During August the forces at work built 6¼ miles of road in addition to completing 2½ miles grubbed and cleared in July, making a total of 13 miles built since July 1.

Contractors Wyatt & Scott, for section 4 (7½ miles in length), built 2½ miles of roadway, making a total of 6½ miles since commencement of work.

Sections 1, 2, 3, and 5 had been placed under contract with William Z. Partello, but he having failed to commence work, Government crews were organized early in July, under the progress clause of the contract, and placed at work on sections 1, 2, and 3. On September 2, Mr. Partello having still failed to commence work, he was given notice of the annulment of his contract. The work, however, was vigorously pushed by the Government crews. They completed 6 miles that had been cleared in July, partly built 2,200 linear feet of corduroy, making a total of 10 miles of completed road, besides the corduroy, since commencement of work in July.

The road repair crew completed the repair work at Canyon Hill and also removed a large quantity of dirt that had been washed into Gardiner Canyon by a severe storm.

During September, at the beginning of the month, work was progressing at all points where road construction had been planned for the season. Foremen Askey and Wells were working on the line from Firehole River to the West Thumb of Yellowstone Lake, and their parties were within 2 miles of each other. Foreman Williams, with whose crew that of Foreman Humphreys had been consolidated, was at work on the lake shore about 4 miles from the West Thumb. Foreman Martin, who relieved Foreman McCoy, and with whose party that

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of the sawmill had been consolidated, was encamped about 5 miles from the Lake Hotel, and was at work repairing and fixing up the partially constructed road running from the Lake Hotel about 7½ miles around the lake shore.

Foreman Dougherty was encamped a few miles below the Lake Hotel on the river shore and was at work on the river road. Foreman Wyatt was encamped about 1 mile above Mud Geyser at work on the river road. Foreman Hart, of the disbanded bridge crew, was at Williams's camp, and, with help from the latter party, was constructing bridges on that portion of the work. Another party, detached from Martin's crew and under Subforeman Henwood, was constructing two large bridges on section 3.

The steamboat, which was temporarily disabled in the latter part of August, was in operation again on the 7th of September.

On September 6 Martin's crew broke camp and moved to the vicinity of the Fountain Hotel, arriving there on the evening of September 7.

I had laid out a system of roads in that vicinity, which it was hoped to complete before the end of the month. The force was first put on that stretch of road which extends from the hotel to the vicinity of the military camp across a wet, swampy district. This party continued here till the end of the season. On the 10th, after an inspection of the entire work, I directed a suspension of all work on the 15th. By that time the road from Upper Geyser Basin to West Thumb of Yellowstone Lake was open for travel, and completed, with the exception of some finishing work upon about 1 mile east of the Continental Divide. The road from West Thumb along lake shore to Yellowstone River was open for travel and completed, except about 2 miles yet to be widened and partly covered with clay. The road from the lake outlet to the Grand Canyon was completed; and 1 mile of road near the Fountain Hotel was opened for travel and completed, except the gravel covering on a short portion. This makes the following results for the three months' work of this season:

Miles of road completed, 53.

This opens the belt road through the principal objects of interest in the Park. The six working parties were discharged on the 15th and marched into Mammoth Hot Springs in 2 days, where they were paid off and quietly dispersed by the 19th.

In conclusion I desire to express my thanks to Lieutenant Chittenden and his assistants for their zeal and hearty coöperation in the work.

Amount expended during the fiscal year ending June 30, 1892, including outstanding liabilities, $75,000.

ABSTRACT OF ALLOTMENTS AND APPROPRIATIONS.

Allotments.

Under the appropriation of—	
1883	$23,570.03
1884	23,000.02
1885	23,209.37

Appropriations.

By act approved—	
August 4, 1886	20,000.00
March 3, 1887	20,000.00
October 2, 1888	25,000.00
March 2, 1889	50,000.00
August 30, 1890	75,000.00
March 3, 1891	75,000.00
Total of allotments and appropriations	334,779.42

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Money statement.

July 1, 1891, balance unexpended	$132,980.73
June 30, 1892, amount expened during fiscal year	132,885.81
July 1, 1892, balance unexpended	94.92
July 1, 1892, outstanding liabilities	94.92
Amount (estimated) required for completion of existing project	197,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1894	150,000.00

REPORT OF LIEUTENANT H. M. CHITTENDEN, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minn., January 26, 1892.

MAJOR: In compliance with instructions contained in a personal note from yourself, dated Livingston, Mont., September 14, 1891, to prepare "a complete and thorough report" of the operations in the Park under your direction during the past season, I herewith submit the following:

PLAN OF OPERATIONS FOR SEASON OF 1891.

The unexpended portion of the appropriation of August 30, 1890, and the whole of the appropriation of March 3, 1891, were available, the latter on July 1, making a total of over $130,000. The bill appropriating the first amount required a portion of the work under it to be done by contract. The second bill contained a restrictive clause as to the location of the road to be built, directing that a line be selected from the Thumb of the Yellowstone Lake "by the shortest practicable route to Fountain Geyser."

For the expenditure of this money in compliance with the above special requirements, it was planned to build a road from some point on the Firehole River across the Continental Divide to the West Thumb of the Yellowstone Lake, thence around the lake shore to its outlet; and thence down the Yellowstone River to near the Grand Canyon. For convenience of reference I shall designate these three divisions of the work as the Mountain, Lake Shore, and River divisions, respectively.

It was further contemplated to build a short line of road from the Canyon Hotel to Inspiration Point; to complete the partly constructed road already commenced between Upper Basin and the Lake Hotel; to build several necessary roads near the Fountain Hotel; to open a new wagon trail from the new road in Gibbon Canyon to Lower Basin so as to cut out the difficult Canyon Creek hill; to build a road cutting out Norris hill; to carry on extensive repairs of existing roads; and to execute a topographical survey of the country along the principal roads.

The line of the Lake Shore and River divisions and the short road near the Grand Canyon had been surveyed the previous season, divided into sections, and the construction of the road let by contract to the lowest responsible bidders.

The Lake Shore division was divided into two sections, each 5.7 miles long. The River division was divided into two sections, one 7.1 miles long and the other 7.5 miles. The road at the Grand Canyon constituted a separate section.

The contract work was therefore composed of—

	Miles.
Section I, Lake Shore from West Thumb towards outlet	5.7
Section II, Lake Shore from Section I towards outlet	5.7
Section III, River from Lake Hotel towards Grand Canyon	7.1
Section IV, River from Section III towards Grand Canyon	7.5
Section V, from Canyon Hotel to Inspiration Point	1.3

Sections I, II, III, and V were let to Mr. William Z. Partello, of Washington, D. C.; Section IV to Wyatt & Scott, of Gardiner, Mont. The work on the Mountain division and all the other smaller portions were to be done by hired labor. Delays of one kind and another postponed the commencement of the work until the middle of June, and the extraordinary continuance of rainy weather from that time to the end of the month promised to seriously hamper operations. Another embarrassment arose from the fact that Mr. Partello, as late as June 15, had given no intimation of his intention to execute his contract, and left us in doubt as to what course we should have to pursue.

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SUMMARY OF SEASON'S WORK.

On the Mountain division a road has been opened the whole distance from the Firehole River to the West Thumb, about 15 miles. This road is practicable the whole length, although too narrow on the portion where the work was last done. For most of the distance the road is as thoroughly completed as any in the Park. From Firehole River the route follows the valley of Spring Creek to the pass over the Western Divide. For 3 miles it runs along Spring Creek through a rocky and picturesque canyon. The pass over the Western Divide is about 1 mile long, and lies in a rocky gorge of much beauty.

From the divide to the lowest point in Shoshone Valley, via the middle fork of Heron Creek, the road descends by a uniform grade of less than 6 per cent for a distance of about 1½ miles. It thence ascends at the same grade to some high ground between the middle and eastern forks of Heron Creek, from which a fine view is had of Shoshone Lake and the Teton Mountains. From this point the road ascends the valley of the east fork of Heron Creek about 4 miles to the Eastern Divide. About half of this distance lies through open country. For 1½ miles east from the summit the road passes over a rolling country, and then commences the descent to the lake. This is accomplished by a nearly uniform grade of 5 to 6 per cent. The road comes suddenly in view of the lake and surrounding country at a point where it rounds a sharp spur of the hills. The timber has been cleared away at this point, giving a fine view. Half a mile further on the road passes the shore of Duck Lake. It reaches the geyser formation and joins the Lake Shore road about a quarter of a mile back from the lake and near the interesting springs and "Paint Pots."

The Lake Shore division extends from this point about 11.4 miles, and follows closely, or at but little distance back, the lake shore for the whole distance. For 1½ miles it passes over the lake shore geyser formation. Along Bluff Point it is built over the hill, a 4 per cent grade giving a good view of the lake. From Bluff Point the road runs through a timbered tract about a mile, when it strikes the west end of a long sandy beach, which extends a distance of 2 miles. For about 1 mile of this distance the beach is really a bar about 100 feet wide and 5 feet high, cutting off a portion of the lake. The whole beach line forms nearly the quadrant of a circle. From the east end of the beach to the end of Section II the road passes through timbered country at varying distances from the lake shore up to half a mile.

The Lake Shore road, as a whole, is about two-thirds completed. Along the geyser formations there are numerous tracts scarcely touched. Across Bluff Point our time enabled us to no more than open a road. The beach road is almost untouched, except half a mile of corduroy on the eastern end. A continuation of the corduroy work was discontinued by yourself at your last inspection, and directions were left to cover the sand with dirt without any intervening material. The sudden cessation of operations prevented further work here. On the road from the beach east there is a stretch of about half a mile where there is no grading done, the roadway lying on the natural surface of the ground.

The remainder of the Lake Shore road commenced in 1889 was barely cleared of timber, not entirely so in some places, and was full of roots which had not been grubbed out. The bridges had all been built and absolutely necessary grading done. Of this piece of road we found it necessary to thoroughly grade about 2 miles, to clear the roots out of the whole portion, and to do various other pieces of work to render it easily passable. For the most part it is a surface road without grading, but still in very good condition.

The River division includes Section III of Partello's contract, and Section IV let to Wyatt & Scott. Section III extends from the hotel to the vicinity of Mud Geyser. It is 7.1 miles long and is entirely opened, although certain portions are not yet completed. From Mud Geyser to the rapids of the Yellowstone the work was done under contract of Wyatt & Scott. This portion of the road is very well built, although still incomplete in certain places. The whole River division is about 14.6 miles long.

At the Fountain the only work done was to open a line from the hotel to the vicinity of the military camp on Nez Percé Creek. I very much regret that we were unable to complete this road. All other portions on the construction work planned were left untouched.

SURVEYS.

The survey party covered all the old roads and all the new roads but about 4 miles of the Mountain division. My instructions for this work required particular attention to be given to the following points:

(1) General topographical features in immediate vicinity of roads.

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(2) Location of all prominent points within reach of stadia.
(3) Position and depths of ravines, and slope of hillsides where roads might possibly be located.
(4) The size and fall of streams with a view to supplying tanks for sprinkling roads.
(5) Nature of soil, location of swampy ground, etc.
(6) Position and nature of rock deposits, with especial care to note such as might be available for road covering.
(7) Nature of timber, whether green, dead, fallen, or full of underbrush.
(8) Levels to be taken with great care, and to be verified by releveling wherever there is the slightest doubt as to accuracy of work.

The work is now being platted on a scale of 1,000 feet to the inch. This will furnish a useful map for future work.

BRIDGES.

The bridge work of this season presented no unusual features. The methods of construction hitherto adopted were in most cases followed. The greater part of the bridge work occurred on Section 4, where the various streams flowing from the divide between the Missouri and the Yellowstone fall into the latter. There were ten of these bridges in all, mostly low, and of lengths varying from 12 to 112 feet. On Section 3 there was one bridge just above the upper rapid of the Yellowstone where a small stream falls into the river. The other stream crossings on this section were effected by means of culverts frequently made without the use of any sawed timber whatever. On sections 1 and 2 there are two large bridges about 100 feet in length and 15 to 20 feet in height. There are also numerous culverts and small bridges. On the Mountain division there are three bridges of considerable size and a large number of small ones. Along Spring Creek especially there are many crossings. Owing to the impracticability of getting lumber for these bridges they were all constructed, except the covering for the three large ones, from rough material cut from the roads. All the smaller crossings were built of corduroy, covered over with dirt, making a continuous roadway. Two of the large bridges on this division were built of timber hewn in the vicinity of the work. These were built by Foreman Askey on the road from the lake to the top of Eastern Divide. The largest bridge on the work is over the West Fork of Heron Creek, about half way up the hill to the Western Divide. The stream here flows through a rocky canyon, deep and narrow. In the absence of sawed timber with which to construct a regular trestle four cribs were built, two as abutments and two as interior piers. The size of the cribs is 6 by 20 feet and their height about 25 feet. The total length of the bridge is about 80 feet. In the bottom of the cribs was deposited a small quantity of stone, which should be increased when work again opens up. The cribs are thoroughly interbraced and the bridge seems to be a successful structure of its kind.

Under the head of "Remarks on road construction" I have made some suggestions as to bridge work which may be of value. (Page 3451.)

SUPERVISION OF THE WORK.

The following has been the assignment of help on the various portions of the work:

The work on the Fountain road and on the Mountain division was under my personal supervision and I did all the work of selecting and laying out the road. I also selected the road over Bluff Point on the Lake Shore road and first mile and a half on section 3, River road, and a portion of section 4, in the vicinity of Trout and Antelope creeks. I mention particularly this latter piece of road and also that over Bluff Point, as these selections were against the advice of my assistants and I desire to relieve them from any criticism if the selections prove poor ones.

Mr. E. Lamartine, overseer, was stationed at the lake, charged with general supervision of the work on sections 1, 2, and 3, the transportation of supplies from the lake to the various camps, the management of the sawmill, and the supply of necessary lumber to the bridges.

In charge of the engineering work on sections 1 and 2 was Mr. Wm. Graham, United States assistant engineer. Mr. Chas. A. Hunt, United States assistant engineer, was in charge of sections 3 and 4, River Road.

The foremen were as follows: On Mountain division, Mitchell, Askey, and A. C. Wells; on Lake Shore division, W. W. Humphreys (party afterwards consolidated with that of Williams), R. Williams, M. McCoy (relieved by John Martin); on River division, J. H. Dougherty and W. C. Wyatt. The foreman of sawmill was John Martin, and of bridge crew, J. H. Hart. The general help in the office was one time-

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keeper, one receiver of materials, and one laborer. The organization and pay of the various parties were as follows:

Office help:		
1 timekeeper	per month..	$100.00
1 receiver of materials	do..$100 and	75.00
1 receiver of materials	per month..	65.00
1 cook	do....	40.00
Varying number of laborers	per day..	1.75
Field help:		
1 overseer	per month..	150.00
2 assistant engineers	do....	125.00
1 rodman	do....	50.00
Varying number of laborers	per day..	1.75
Survey party:		
1 assistant engineer	per month..	125.00
1 rodman	do....	90.00
2 rodmen	do....	60.00
2 flagmen	do....	50.00
1 cook	do....	50.00
1 team	per day..	5.10
Steamboat:		
1 deck hand	per month..	75.00
1 engineer	do....	75.00
1 deck hand	do....	60.00
1 cook	do....	55.00
Varying number of laborers	per day..	1.75
Varying number of teams	do....	5.10
Road-repair parties:		
4 assistant master laborers	per month..	60.00
10 laborers	per day..	1.75
5 teams	do....	5.10
Bridge crew:		
1 foreman	per month..	90.00
1 cook	do....	60.00
8 laborers	per day..	1.75
Varying number of teams	do....	5.10
Transportation of supplies, an average of 8 teams	do....	5.10
Sawmill:		
1 master carpenter	per month..	100.00
2 sawyers	do....	100.00
2 engineers	do....	65.00
1 blacksmith	do....	60.00
1 cook	do....	60.00
1 saw-setter	do....	50.00
22 laborers	per day..	1.75
12 teams	do....	5.10
Six construction parties (average personnel):		
1 foreman	per month..	90.00
1 subforeman	do....	75.00
1 cook	do....	60.00
1 blacksmith	do....	60.00
45 laborers	per day..	1.75
15 teams	do....	5.10

The total amount of road constructed is about as follows:

	Miles.
Mountain division	15
Lake Shore division, sections I and II	11.4
Lake Shore division, old road	2
River division	14.6
Fountain Hotel road	1
	44
Partially completed old road opened up	9
Total length of road opened	53

From the 44 miles new road constructed there should be a deduction of at least 5 miles for uncompleted portions, leaving in all say about 39 miles of road work, all of it equal to, and much of it better than, any previously done in the Park.

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COST OF WORK.

Below is an approximate statement of the cost of the work since June 1.

The price of board per day is arrived at as follows:

Total cost of subsistence supplies at Cinnabar	$15, 183. 93
Total cost of transportation in Park	4, 157. 13
	19, 341. 06

Total number of days worked, 29,156.

Price per day, $0.66½.

The cost of material is estimated as follows:

I assumed that the material has on an average a life of three years. Hence I charged to the work of this season one-third of its total cost and apportioned this third among the different portions of the work according to the number of days' work done on each.

This gives an average charge of 4.45 cents per day's work.

APPORTIONMENT OF EXPENSES AMONG THE VARIOUS WORKING PARTIES.

The following table apportions the cost of labor, team hire, subsistence, and material among the various parties engaged in the work. The first eight names in the first column are those of foremen in charge of construction parties. The rest of the names need no explanation.

Designation of party.	Labor.	Team hire.	Board.	Material.	Total.
Wells	$6, 664. 89	$5, 330. 52	$3, 085. 74	$207. 09	$15, 288. 24
Askey	6, 615. 04	5, 779. 32	3, 277. 78	219. 98	15, 892. 12
Humphrey	2, 421. 14	2, 045. 10	1, 155. 29	77. 54	5, 699. 07
Williams	4, 928. 20	3, 486. 36	2, 296. 31	154. 11	10, 864. 98
McCoy	2, 815. 02	1, 897. 71	1, 410. 36	94. 66	6, 217. 75
Martin	1, 432. 83	1, 342. 32	697. 56	46. 81	3, 519. 52
Dougherty	3, 894. 46	2, 698. 41	1, 850. 51	124. 19	8, 567. 57
Wyatt	1, 564. 19	2, 139. 96	833. 87	55. 97	4, 593. 99
Sawmill	3, 081. 98	3, 423. 63	1, 596. 76	107. 16	8, 209. 53
Survey	1, 301. 99	357. 00	404. 02	27. 11	2, 090. 12
Bridges	1, 364. 83	807. 28	511. 15	34. 29	2, 717. 55
Steamboat	1, 027. 66	1, 060. 35	481. 30	32. 29	2, 601. 60
Office	1, 210. 81	945. 03	389. 09	26. 11	2, 571. 04
Field work	1, 931. 19	1, 184. 22	644. 48	43. 25	3, 803. 14
Repairs	1, 194. 12	1, 443. 30	615. 29	41. 29	3, 294. 00
Road rollers	26. 25	683. 90	91. 55	6. 07	807. 77
Transportation	....	4, 111. 69	317. 41	21. 30	4, 450. 40
Total	41, 474. 60	38, 736. 10	19, 658. 47	1, 319. 22	102, 188. 39

Cost of the various portions of the work per mile.

MOUNTAIN DIVISION.

	Miles built.	Cost.	Cost per mile.
Foreman Wells	5. 4	$14, 709. 12	$2, 723. 91
Foreman Askey	9. 73	16, 460. 07	1, 691. 68
	15. 13	31, 169. 19	2, 060. 09

LAKE SHORE DIVISION.

Foremen Williams, Humphrey, and McCoy	8	25, 551. 32	3, 318. 91

RIVER DIVISION.

Section 3.			
Foreman Dougherty	2. 75	9, 183. 43	3, 339. 42
Foreman Wyatt	2. 75	5, 229. 84	1, 901. 76
	5. 5	14, 413. 27	2, 620. 59
Section 4.			
Contract	7. 5	34, 805. 25	4, 640. 70
	36. 13	106, 939. 03	2, 959. 84

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If we allot to this work its proper share of office, traveling, survey, and other expenses, it will raise the above figure to nearly $3,300 per mile.

COST OF LUMBER.

There were manufactured about 410,000 feet of lumber at a cost of $7,689.45, or about $18.75 per 1,000. This does not include pro rata share of office and other expenses, which would probably raise the cost to $20 per 1,000.

PARTELLO'S WORK.

The terms of the contract under which work on sections 1, 2, and 3 was to be done contemplated only such work (excavation of rock, earth, etc., and clearing of land) as is included in the above table of expenditures. The work on this piece of road was all done by Foremen Humphreys, Williams, McCoy, Dougherty, and Wyatt. Taking the sum of expenditures under their names from the above table we have—

Cost of work on sections 1 and 2	$35,943.36
Less work done by McCoy on old road	236,25
Total	35,707.11

REMARKS ON ROAD CONSTRUCTION IN THE YELLOWSTONE NATIONAL PARK.

Cost per mile of road construction.—The estimates heretofore submitted as to cost of road construction in the Park seem to me in need of thorough revision.

In the report of the Chief of Engineers for 1887, page 3175, Captain Kingman gives the following specifications adopted by him in his work during the four seasons, 1883–1886 inclusive.

"I therefore proposed that all roads in the National Park should be made at least 18 feet wide and well rounded up in the center and provided with suitable side ditches and cross culverts; that all trees be removed for a width of 30 feet; and on sidehill cuttings the fill be retained by a dry stone wall and that an ample ditch be placed on the uphill side to catch the snow water and carry it to the natural water courses; that all culverts be of stone or 3-inch plank; and that all bridges be well constructed of sawed lumber."

Then follows a statement as to the cost per mile of a road thus built.

"After carefully examining the country through which the roads would have to pass, I was satisfied that suitable ones could not be built for a less average price than $1,000 per mile."

The only revision of this estimate that appears to have been made is contained in Major Allen's report for 1889 (Report, Chief of Engineers, 1889, page 2859). In submitting an estimate of cost of completing existing project, Major Allen says: "The cost can only at present be given approximately at $2,000 per mile."

As to the character of the work covered by this estimate the following may be cited from Major Jones's report for 1890 (Report, Chief of Engineers, 1890, page 3593): "Evidently the estimate does not look beyond clearing the line of trees and brush and a moderate grading, making what is usually called a country road." It will be noted that this estimate is double the original one of $1,000 per mile.

I was unable from the first to see how a road built according to the original specifications could be made to cost as little as $1,000 per mile, and the result of my own experience is very much at variance with the above. In the first place, it would be impossible to pick out from the 60 miles of road already constructed at the beginning of this season, a continuous half-mile which will satisfy the above conditions. In most places the road lacks the width of 18 feet. In many places teams can not pass. In very few are there adequate ditches, if any at all. I recall but one place where in sidehill cutting a ditch has been "placed on the uphill side to catch the snow water and carry it to the natural water courses," and that is on a piece of road recently constructed under the direction of Major Jones. For the most part the roads pass along the natural surface of the ground, going over all irregularities of surface instead of cutting and filling to secure a good grade. The work is, therefore, the very simplest of its kind; mere excavations of side ditches or barrow pits and deposit of the dirt in the immediate vicinity to form the roadway. In very few places, so far as I have been able to discover, has extra hauling been done for the purpose of graveling miry places. Moreover, the work was less than half the average distance of recent work from the base of supplies, which consequently much reduced its cost.

We have built by contract during the past season about 7½ miles of road where the specifications given in Captain Kingman's report have been pretty rigidly adhered

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to, and where, in addition, careful attention has been given to the question of grades. The following are the amounts of the several kinds of work done:

Solid rock excavation	cubic yards..	3,712
Loose rock excavation	do......	1,346
Earth excavation	do......	64,785
Riprap	do......	225
Clearing	acres..	8.7

Taking the lowest reasonable prices for this work and it will cost at least $3,430 per mile, not including bridges, superintendence, and a proper proportion of office, traveling, and other expenses. This covers simply the cost of work necessary to make a good dirt road. It contemplates clearing the roadway a space of 30 feet, grubbing out all roots, and removing all rocks; the grading of a roadway 18 feet wide and raised in the middle 6 inches above the edges; the construction of ditches 5 feet wide on top, 2 feet on the bottom, and 18 inches deep; the construction of strong culverts and bridges wherever necessary; the proper revetment of all slopes where necessary to contain the roadway, and lastly the maintenance of easy grades instead of taking hills and valleys as they come regardless of their slope.

It does not contemplate surfacing with any other material than that found along the roadway. It leaves out of consideration entirely the question of a thoroughly constructed gravel or macadamized road. The cost of the latter will be referred to later.

Now, what do the figures show as to the actual cost of road construction in the Park?

Under Captain Kingman, 1883–'85, $69,779.42 was expended, resulting in the construction of 30.5 miles of road. This gives about $2,200 per mile. The total amount expended on roads in the Park to June 30, 1891, was $206,623.82, and according to our survey this summer the following so-called completed roads have been constructed:

		Feet.
North boundary of the Park to Mammoth Hot Springs		24,860
Mammoth Hot Springs to Norris		103,859
Norris to end of new road (Gibbons Canyon)		48,806
Lower Geyser Basin to Upper Basin		53,021
Norris to Grand Canyon Hotel		62,545
		293,093
		Miles.
		55.5
	Miles.	
From Lake Hotel along shore	7.4	
From Upper Basin along Firehole	3.5	
	10.9	
This road not over half completed, say		5.4
		60.9

This gives something over $3,300 per mile.

It should here be stated that considerable sums have been expended annually in repairs, in part on the old wagon trails and in part on the new roads. It is impossible from the data contained in the reports to make a satisfactory estimate of the amount of this item and it has therefore been included throughout the entire work, thus doing no injustice to any particular portion. Moreover, it should be noted that "repairs" will usually be nearly in inverse proportion to the thoroughness of original construction. Where only $1,000 per mile are expended in construction annual repairs must necessarily be extensive, being really road completion rather than ordinary repairs. This is especially true of the roads in the Park. In several places the road as first built has been entirely altered in location; in others very much altered in construction. It appears, therefore, that a portion at least of "annual repairs" is properly charged to original construction.

Coming to special instances we find in Lieutenant Craighill's report (Report of Chief of Engineers, 1890, page 3596) that the Gibbon Canyon road, constructed by him and one of the most satisfactory pieces of road in the Park, cost $4,073.70 per mile. This road, moreover, presents no extraordinary difficulties of construction.

The road at the Grand Canyon, also a well-built road except for its steep grade, cost $8,365.66 per mile. (Same report, page 3595.)

The road from the Lake Hotel toward Upper Basin cost $1,627.14 per mile; but as before said this is not more than half completed, which would indicate a cost of $3,250 per mile. (Same report, page 3596.)

As already shown the cost of this season's work is about $3,300 per mile. It

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should, however, be noted that the distance from the base of supplies was the greatest at which work has yet been done, being for part of the work about 75 miles. This great distance caused an average loss of six days' work for the entire force in going to and returning from the work at the beginning and end of the season. Considering that the season was only two months long this relative loss will be seen to have been considerable. The cost of subsistence was also greatly increased by long haul of supplies.

It is thus apparent that the roads in the Park can not be constructed at a cost of $1,000 per mile. Nor can they anywhere else. The following are figures from a standard work on engineering:

Average cost of earth work with a haul of 100 feet, all kinds of soil, wages $1 per day for man, $2.50 for team, is 13.8 cents per cubic yard, which would give, at the rate of wages we have to pay, about 35 cents per yard.

In like manner rock work will cost about $1.50 per yard and other items in proportion.

There is one item in road construction in the Park that requires especial attention: that of clearing. A fair estimate in railroad work is $50 per acre, and, allowing for the extra cost of labor in the Park, a corresponding figure would be something over $70 per acre. But clearing as required by our specifications can not be done at that figure. The nature of the work is especially difficult. The width of roadway necessitates grubbing every stump. No burning of timber is allowed and this necessitates the hauling of trees, limbs, stumps, roots, and all, into the timber on the side of the road. I have never been through timber country where there is so great a quantity of fallen trees and underbrush as in the park, frequently making it absolutely impassable on horseback. This condition of the country often, in fact usually, requires the opening of side roads to make room for hauling away the timber from clearing. The cost is, therefore, unusually high for work of its class. The following is an accurate record of the cost of clearing an average piece of timbered land. The work was done by a party that had already been in the field two months and was thoroughly familiar with the work. It can be taken as a low figure for work of its kind:

	Days' work.	
6 grubbers, 4 days	24	
2 choppers, 4 days	8	
2 sawyers, 4 days	8	
1 climber, 4 days	4	
1 piler, 4 days	4	
4 teams, 4 days	16	
Total, 48 days, at $1.75		$84.00
Teams, 16 days, at $5.10		81.60
Board, 64 days, at 75 cents		48.00
Material		2.82
Total		216.42

The space cleared was 30 feet wide and 1,300 feet long, 39,000 square feet, or .89 acre. This gives $243 per acre, which, with a fair proportion of office, travel, and other expenses, would make $250 per acre.

Applying these figures to the work actually done, as given above on a piece of road construction during the past summer, and with proper allowance for office, bridge, and other expenses, it will be found to fall not far below $5,000 per mile.

On the whole, then, my estimate of the cost of road construction in the Park is that it can not be done in accordance with the specifications already laid down at a less average figure than $4,000 per mile.

I also estimate that to make existing roads conform to our specifications will require an additional outlay of $1,000 per mile.

As already stated this contemplates the construction of a dirt road, using only such material as is found where the road is built. It is needless to say that a road so constructed can not be considered a "completed" road. A journey through the Park after a period of rainy weather, occurring when traffic is heavy and continuous—a condition which existed for several weeks this season—leaving the roadway a mass of mire which often becomes almost impassable, or, at other times, when, in long continued dry weather, travel has ground the road surface into a fine powder from 2 to 6 inches deep, which almost suffocates the traveler with dust, will speedily convince one that the problem of road construction in the Park has yet to be solved.

There are two solutions of the problem. One has already been recommended in previous reports, that of macadamizing the roads. This is, of course, the true solution, but can not be realized for many years to come. An approximate estimate of the

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st of thoroughly macadamizing the roads giving a depth of 12 inches of broken one in the center of the road and 8 inches on the edges, indicates $6,000 per mile, about $1,250,000 for all roads included in the existing project. The cost might be ore than this, for no experiments have been made which settle the question of the uality of rock easily accessible in the Park, and, judging from the action of the eather on frequent outcrops, suitable material is not very plentiful. A very ood substitute for the plan of macadamizing the roads, and one more immediately practicable and much less costly, is that of thoroughly graveling them. here is an abundance of good road gravel in the park and of very general distribution. To cover the roads with an average depth of 16 inches in the center and 8 nches on the edges, supposing the average haul to be one-fourth mile, will cost approximately $2,500 per mile. This will give a road bed inferior only to a macadamized road and amply fulfilling the necessary conditions of park travel.

We have then the following estimate:

For construction of new road to complete present project, including graveling as above, 100 miles, at $6,500 per mile	$650,000
For completion of old road, including graveling 100 miles, at $3,500 per mile	350,000
	1,000,000

GRADIENTS.

So far as I can discover from previous reports, but little attention was given to the question of grades prior to the report of Lieutenant Craighill for the season of 1890.

Captain Kingman refers to the grades up Golden Gate Hill as "admissible," and averaging one-ninth or 11 per cent for the entire hill.

In Lieutenant Craighill's report for 1890 he has the following as to gradients:

"My conclusions are therefore as follows:

"Wherever the ground will permit, and the cost is not excessive, a grade of 7½ per cent should not be exceeded. Where, for exceptional reasons, this is not practicable, the grade should not exceed 9 per cent for long hills and, for short ones of not more than 100 or 200 feet, 10 per cent may be allowed. Within these limits the natural surface of the country may be followed."

Below are examples of the heavier grades on existing roads as determined by the survey of this season. Of the lighter grades ranging from 5 to 10 per cent there are many. The figures for each section of road given are consecutive and denote the rise or fall in feet for the 100 feet immediately preceding. The direction is from Gardiner south.

Section of road between Gardiner and Mammoth Hot Springs, ascending: 7, 11.8, 12.1, 13.6, 11.2, 9.3, 8.4, 9.1, 7.8, 11.1, 11.3, 11.6, 10.8, 12.2, 13, 10.8, 7.5, 10, 9.4, 11.9, 14.4, 15.2, 11.7, 8.5.

Five sections of road up Golden Gate Hill, within 3 miles of Mammoth Hot Springs, all ascending—

First section: 7.8, 15.4, 12.2, 13.6, 14.3, 16, 9.5, 9.2, 13.4, 14.1, 15.7, 13.1, 15.7, 13.7, 11.5, 10.4, 8.9.

Second section: 2.4, 12.6, 13, 7.2, 5, 9.6, 14.6, 21, 17.3, 9.7, 10, 10, 4.9.

Third section: 1.6, 11.8, 20.3, 6.9.

Fourth section: 7.8, 10.8, 14, 14.1, 13.8, 11.2, 6.8, 10, 9.

Fifth section: 8.5, 11, 12.4, 13.1, 7.8, 9.1, 4.7, 11.3, 13.6, 15.4, 5.1.

North side of Norris Hill, ascending: 6, 11.9, 14.1, 10.8, 14.5, 17.3, 1.1, 7.6, 6, 14.8, 9.6, 10.5, 6.2, 11.9, 4.3.

South side of Norris Hill, descending: 6, 10.1, 11, 15, 12.6, 12.8, 14.6, 16.2, 14.2, 6.8.

Hill north of Gibbon Meadows, descending: 8.9, 10, 12.3, 12.5, 14.2, 10.4, 8.3, 11.4, 12.7, 11.3, 2.4.

Three sections between Norris and the Grand Canyon, descending—

First section: 2.1, 12.8, 15.9, 17.4, 4.5.

Second section, ascending: 11.6, 14.4, 16, 12, 16.5, 18.2, 14.7, 4.6.

Third section, ascending: 9.6, 15.3, 13.3, 14.4, 13.7, 13.3, 14.5, 15.4, 11.6, 11.1, 17, 7.4.

It is seen from these figures that the grades of the park roads range all the way from 0 to 21 per cent.

* * * * * * *

In executing the past season's work I was limited by my instructions to a grade of 12 per cent. But I soon found that it was perfectly practicable to carry our roads, wherever it might be necessary, at a grade not exceeding half the above figure. The road over the Mountain division lies for 15 miles through a mountainous country, crossing the Continental Divide twice. The whole distance was accomplished without exceeding 6 per cent, and I am convinced that a careful survey, before the work

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began, might easily have reduced this to 5 or 4 per cent without seriously lengthening the line. The importance of light grades on the principal roads is so great that I recommend that the figure of 5 per cent be not exceeded in the future. It will almost invariably be found that an adherence to this rule will add much to the appearance as well as the usefulness of the roads.

Of course there may be exceptional instances where side roads are to be run to special points not subject to main line heavy traffic, and where, the question of grade being less important, the above figure can be exceeded to advantage.

Diagrams* showing grades on existing roads are submitted herewith.

EXECUTION OF ROAD WORK.

The question of the best method of executing road work in the National Park has been frequently referred to in previous reports. In a letter to the Chief of Engineers, dated August 12, 1886, asking for certain authorities in the prosecution of work in the Park, Captain Kingman says: "It is impossible to execute this work by contract, for it is of such a nature that it would be impossible to accurately describe it without surveys that would often cost as much as the work itself."

The experience of the past season, when part of the work was done by contract, has proven this statement to be substantially correct. The estimate based upon the survey of the previous year proved wholly misleading. The execution of the work was in no way more satisfactory than that done by ourselves. The extraordinary range of bids upon the work (clearing of land ranging from $27 to $250 per acre) shows that it is next to impossible to get a reasonable contract. It is certain that, with its present equipment of working implements, tents, etc., and by saving the extra work of surveys, inspection, measurement, advertising, etc., the Government can do the work by hired labor more economically and satisfactorily than by contract.

In executing the work that can be done, say by an appropriation of $100,000, the following will serve as a useful organization of working force:

In the field there should be one overseer, who is also a competent civil engineer, to take general charge and direction in absence of the officer in charge. There should be two assistant engineers in local charge of portions of the work, whose duties are to do the instrumental and other work necessary to an accurate selection of route and all other work involving engineering skill.

Supposing the work to continue from the middle of June to the middle of October, there should be four working parties of about 45 laborers and 15 teams each.

The teams should, in my opinion, be hired in open market, not by contract, if this can be legally done. A competent man and good judge of teams should take charge of hiring and keeping up the necessary number of teams as well as of keeping their time and attending to all questions connected therewith.

There should also be a timekeeper of the laborers' time, who should attend exclusively to all matters necessary to the accurate preparation of pay rolls.

There should be a receiver of materials, whose duty is the management of all matters pertaining to the Government property, and to the securing and forwarding of supplies to the men. The transportation of supplies should be accomplished by a separate force of teams under the immediate charge of the receiver of materials.

The construction of bridges should be under the same foreman who has charge of the sawmill. The two crews will then be worked together, as they should be, and much economy of time and labor will result.

The office work during the rush of the season requires at least one clerk, one copyist, and two assistants.

The force recommended is then as follows:

Office: 1 clerk, 1 copyist, 2 assistants, 1 receiver of materials, 1 team hirer and timekeeper, 1 timekeeper for laborers.

Field: 1 assistant engineer and overseer, 2 assistant engineers, 1 messenger.

Four working parties, consisting each of 1 foreman, 1 subforeman, 1 cook, 2 cookees, 1 blacksmith, 1 water-carrier, 45 laborers, 15 teams.

Sawmill and bridge crew: 1 foreman, 2 subforemen, necessary skilled help, common laborers, and teams.

For special work, such as surveys, special organization would be required.

It is believed that the above force can be kept in the field for four months with an appropriation of $100,000, and have enough funds to cover all ordinary outside expenses.

In the matter of clearing I would submit for your consideration whether it would not be better to increase the width of roadway cleared to 50 feet. This would enable us safely to burn all smaller brush and leave enough space outside the roadway proper to pile logs and stumps until they are sufficiently seasoned for burning. I think this would facilitate the work of clearing, and it would certainly improve the appearance of the roadway.

*Not printed.

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GENERAL CONSIDERATIONS.

The small amount of money hitherto appropriated for work in the Park and the extensive project adopted have necessarily caused the work to be done in a manner which the engineer in charge would probably not have approved if he had had adequate means at his disposal.

In his report for the year ending June 30, 1889, Lieutenant Craighill thus refers to the matter:

"When the road was built between Mammoth Hot Springs and the Gibbon Canyon, on account of scarcity of funds it was deemed best in several places for short distances not to follow the best route, which was also the most expensive. In each of these cases the road goes over the hill at a steep grade where it might go around it almost on the level."

The same remark, with slight modification, applies to all the roads hitherto built in the Park except the lower half of the Gibbon Canyon road.

However steep a hill may be the route over it almost always varies less from a right line to the other side than the route around it. Economy of construction would, therefore, indicate the former as most desirable. But this consideration should no longer prevail. All principal objects of interest in the Park are now accessible by wagon. Hence the aim of road work need no longer be to construct the greatest possible length of road with a given amount of money, but rather to see that the road actually constructed conforms strictly to the conditions of good work.

The selection of roads in the National Park should obviously proceed on different principles than obtain in the selection of roads for ordinary traffic. The former are emphatically *park* roads. Their use is principally for tourist traffic, secondarily only for the hauling of freight. As recommended by Major Allen in his report for 1889, "all roads in the Park should be well constructed not only with a view to permanency but also to appearance." In their selection the shortest distance between the terminal points should not be the object of first importance. While the road ought not to be unnecessarily lengthened, it should be selected with a view of securing easy grades and proximity to as many as possible of the features of interest near which it passes. In short, everything should be done to reduce to a minimum the irksomeness of the long drives that separate the principal points of interest in the Park. A prominent example of the absence of these essentials is seen in the road between Norris and the Yellowstone River. The roadbed is here as good as any in the Park, and yet the road is the subject of constant criticism on the part of tourists. The reason is that there are many miles where the road follows nearly a straight line with little attempt to avoid the hills, and where the view ahead is one continuous succession of ups and downs visible along the narrow roadway cut through the woods. As soon as the farthest eminence is passed another interminable succession of hills comes into view, producing a sense of monotony equaled only by that experienced in riding over the featureless prairie. It goes without saying that if this road had been made more winding, following the valleys and avoiding the hills, thus by its short views ahead giving the tourist a continual sense of expectancy, instead of treating him to the long perspective of a monotonous roadway ahead of him, the whole effect would have been better. The importance of securing these features may not be very apparent at the time the road is being built, but it is fully appreciated by those who subsequently use it.

The proper location of a road through a country like that in the Park is often exceedingly difficult. Very much of the country is densely wooded. It is often impossible to get an idea of the ground beyond a radius of 300 or 400 feet. A great amount of careful examination is necessary before an engineer can feel satisfied that he has secured the best location. Moreover, even in an open country, the selection of the best line over ground as rough and broken as many tracts in the Park should receive a great deal of skillful attention to secure a line which shall pass subsequent inspection as the best one that could be found. So obvious a requirement would not be suggested if the work of the past summer, a portion of which, owing to the lateness of the season was commenced without a preliminary survey or even a reconnaissance, had not shown how easily a good road might have been made a very bad one by simple ignorance of the nature of the country through which it was to pass. In my opinion no future road should be built in the Park until a careful instrumental survey has located and marked the entire line, and fully made known the nature of the work to be performed.

There is another consideration of importance in this connection. A satisfactory system of roads for the Park will ultimately include not less than 300 miles. The country roads of the United States being almost entirely under the care of local authorities, the park system is unquestionably the most important example of strictly Government roads in the country. These roads, owing to the widespread interest in the National Park are the subject of inspection and criticism, not only of Americans but of people from every part of the civilized world. The standard of this work

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should, therefore, not be that of our country roads, generally nothing but mere wagon trails, but that of the best roads in this country or in Europe.

The foregoing criticisms upon work in the Park are not at all intended as a criticism on the execution of that work. At the time it was done it was impossible, owing to the small amount of funds available, to do better.

The yearly appropriations now are greater than those of three or four years combined in the early history of the work.

The object of first importance then was to render points of interest accessible even by inferior roads rather than to secure the best standard of work. Even in the preparation of estimates, the course adopted was doubtless wiser than to have presented at first an estimate based upon a complete system of macadamized roads. The Park was still to some extent an experiment. Congress had been led to believe in creating it that the revenue from leases and similar sources would suffice for the necessary work of improvement. The principal promoter of the project at the time it was under the consideration of Congress says, "Had not Congress been assured that no demands would be made upon them for annual appropriations, it is very doubtful whether the bill would have ever become a law." But all this is now changed. The wisdom of the act creating the National Park is universally admitted. The argument for improving and protecting it grows stronger every year, and it can safely be assumed that the time has arrived for such a revision of project and estimates as shall place that work upon a basis commensurate with its importance. It is for this reason that I have gone into the matter somewhat extensively.

* * * * * * *

EXISTING PROJECT.

The project hitherto adopted for the improvement of the Yellowstone National Park requires some modification and enlargement to meet the existing demands of the work. Captain Kingman, in 1887, prepared the following project, which has been followed to the present time (Report of Chief of Engineers, 1887, page 3134).

	Miles.
(1) A road from Mammoth Hot Springs to the boundary of the Park toward the terminus of the Park Branch of the Northern Pacific Railroad (about)	5
(2) A road from Mammoth Hot Springs to the Firehole Basin (about)	40
(3) A road from the Firehole Basin to the Upper Geyser Basin (about)	10
(4) A road from the Firehole Basin to the Canyon and Falls of the Yellowstone River (about)	28
(5) A branch from this road to the outlet of the Yellowstone Lake (about)	8
(6) A road from Mammoth Hot Springs to Yanceys (about)	18
(7) A road from Yellowstone Falls over the shoulder of Mount Washburn to Yanceys (about)	20
(8) A road from Upper Geyser Basin via Shoshone Lake and the thumb of the Yellowstone Lake to the outlet (about)	40
(9) A road from Norris Geyser eastward to connect with the road to the Yellowstone Falls (about)	9
(10) A road from the Firehole Basin westward via the Madison Canyon to the boundary of the Park (about)	20
(11) A road from Yanceys via Soda Butte to the boundary of the Park towards the Clarks Forks mines (about)	35
In all (about)	223

For paragraph 2 should be substituted "A road from Mammoth Hot Springs via Norris Geyser Basin to Fountain Geyser Basin."

For paragraph 3 the following: "A road from Fountain Geyser Basin to Upper Basin."

The road mentioned in paragraph 4 should, I think, be dropped from the project. It will not in ordinary circumstances be used as a tourist route, and, for such occasional traffic as may pass over it, inexpensive repairs on the present road will suffice. The Park association omit this line in their advertised route.

Paragraph 5 should be stricken out and for it substituted "A road from the Grand Canyon to the outlet of Yellowstone Lake."

The location of the road mentioned in paragraph 8 has been changed by the act of Congress of March 3, 1891, so that it is now extremely improbable that it will ever be built as originally intended. I, therefore, suggest the following instead of paragraph 8: "A road from the Fountain Geyser Basin via the shortest practicable route to the West Thumb of the Yellowstone Lake and thence via the lake shore to the lake outlet."

Paragraph 10 should be changed to "A road from the west boundary of the Park

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via the Madison Canyon by the shortest practicable route to the road from Norris to the Fountain Geyser Basin."

To which should now be added (12) "A road from Upper Geyser Basin to the south boundary of the Park."

In suggesting the above change in nomenclature, viz: "Fountain Geyser Basin" for "Lower Firehole Basin" and "Grand Canyon" for "Yellowstone Falls" I have followed what has already become an established usage in the Park.

The time has now arrived when the question of opening up important points of interest off the main line of travel should receive attention. Captain Sears in 1887 recommended that, "In addition to the main thoroughfares, good branch roads and trails should be made to the many minor objects of interest off the main line of travel." For example, the Great Fountain Geyser, incomparably the finest formation in the Park and excelled only by the Excelsior Geyser in the magnificence of its eruptions, is at present inaccessible except on foot or horseback. In that vicinity are also many of the finest quiescent springs in the Park. A road should soon be built making a drive of three or four miles so as to include all these points of interest.

Near Mammoth Hot Springs are the Canyon and Falls of the Middle Gardiner River, which come next to the Grand Canyon and Falls of the Yellowstone in grandeur and beauty. A road could be constructed from the Springs passing through this Canyon, around Bunsens Peak, back through Golden Gate Canyon, through the "Hoodoo" formation under the picturesque palisades of Terrace Mountains, returning in rear of the Hot Springs formation to the hotel at Mammoth Hot Springs. This could not fail to be a very popular drive.

A letter was addressed to me early this season by the manager of the Yellowstone Park Association suggesting the construction of a foot and bridle bridge across the Yellowstone River above the falls. At present there is no bridge across that river within the boundaries of the Park except that in the vicinity of Yanceys. It is said by those who have seen the canyon and falls of the Yellowstone from the right bank of the river that the view even excels that from Lookout and Inspiration points. I think the project should include a bridge across the river at this point and a road down the river sufficiently far to take in the most interesting portions of the canyon. To temporarily meet the needs of tourists I would suggest the construction of a bridle bridge across the river just above the Upper Falls. The river here has a clear width of only 70 feet, and a span of 80 feet will give ample room for a safe support. This point is a very interesting one, being in the midst of the heavy rapids of the river and immediately above the brink of the Upper Falls. When a permanent bridge is built there it should be of a style and character in keeping with the magnificence of the surroundings. It has been suggested that a single arch of stone be thrown across the river at this point; and if not too expensive it would certainly be more appropriate than any other form of structure could be.

It is highly probable that tourist traffic between the lake outlet and the West Thumb will in the future be by boat. So much interest is taken in the lake on the part of tourists that to gratify it the transportation people will doubtless find it necessary to place a boat upon the lake. It is probable, in fact, that it will be found to their advantage to carry tourists by water rather than by coach over the long distance of 18.6 miles. The trip by boat consumes about $1\frac{1}{4}$ hours. An arrangement of this kind may be regarded as a certainty in the near future.

In connection with the navigation of the lake the subject has been much discussed of continuing the boat route down the river nearly to the falls. This would certainly be very desirable, if practicable. But it is doubtful if the Yellowstone River can be made easily navigable at any ordinary outlay of money. Captain Kingman says in his report for 1883, "I am of the opinion that they (the rapids) could only be surmounted by the aid of canals and locks or else by locks and dams, either of which, owing to the character of the river and the nature of the bottom and banks, would be very expensive." To enable a boat of sufficient draft for safety on the lake in heavy weather to pass down the river would require a channel from 4 to 6 feet deep. To improve the river so as to secure such a channel would certainly be a heavy and expensive undertaking. But it might be practicable to have a line of boats made especially for the river, flat-bottomed and of only 2 or 3 feet draft, which would materially simplify the problem. The lake boats could then be built on the model of deep-water boats and a transfer be made near the lake outlet to the river boats. There are two serious rapids on the Yellowstone River between the falls and the lake. One of these occurs at Mud Geyser and the other about 3 miles above. The stream is shallow and swift over the entire distance between these points. A project for improvement would require the thorough canalization of the river for a distance of 4 or 5 mlies, including the rapids. Above and below this stretch a moderate amount of dredging and removing of bowlders would, I think, be sufficient. The river falls from the middle of June (its highest stage) to the end of September between 3 and 4 feet, but owing to the vast reservoir formed by the lake the rise and fall are very gradual, while floods are made impossible. A measurement of the river current at the lowest stage

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during the past season indicates a discharge of 1,600 cubic feet per second. I have not given the matter sufficient consideration to be able to submit an estimate of the probable cost of such an improvement.

The subject of the "completion of existing roads" may be considered in connection with the proposed modification in the present project. Along with the execution of annual repairs should be carried on a systematic completion of the present roads, with such alterations of location as may be necessary to rectify their grades and otherwise improve them. The importance of this will be manifest from an examination of the accompanying plots* showing the gain in distance and grade by going around Norris Hill, and the gain in grade around Virginia Cascade. There are many other places where changes may be made nearly as beneficial as the above. Along the entire line of road there is need of rectifying grades, constructing ditches, graveling miry places, and rounding up the road surface to facilitate drainage.

NEXT SEASON'S WORK.

In the event of a new appropriation in time for use next season the following works should first receive attention:

(1) The completion of the system of roads near the Fountain Hotel.

(2) Completion of old road from Upper Basin to beginning of new road at mouth of Spring Creek.

(3) Completion of new road on Mountain division on west slope of Heron Creek Valley.

(4) Completion of new road on Lake Shore division from West Thumb to east end of sandy beach, mentioned in previous portion of report.

(5) Completion of new road at various points on River division.

(6) Construction of new road from lower end of section 4, River division, to the bridge at the head of Grand Canyon.

(7) Construction of a new road from the Canyon Hotel to Inspiration Point.

(8) Construction of a new road from end of present road in Gibbon Canyon to Fountain Hotel.

(9) Construction of a new road around Norris Hill.

(10) If there are sufficient funds over what is necessary to execute the above works it would be well to open a wagon trail along the proposed line from the canyon to Yanceys, so as to make it possible to pass that way during the season of 1893. The full completion of the road from Grand Canyon via Mount Washburn and Yanceys to Mammoth Hot Springs would be a matter of two or three seasons' work, as it will, on the whole, be the most difficult and expensive piece of work in the Park.

The view from the summit of Mount Washburn being one of the finest features of the Park, it is my opinion that the road should be built along the general line of the west trail from the Canyon to Yanceys.

ENGINEER OFFICE.

One of the first needs of the improvement work in the Park is that of adequate buildings for office, storehouse, quarters, and stable. The effort of last year to secure these buildings fell through on account of the unexpectedly high figure of the bids submitted. This matter is one of immediate and pressing importance. For several years the engineer office in the Park has been in a disgraceful little shanty, affording neither room nor shelter. The storehouse is scarcely any protection at all to the material. Moreover, it is wholly inadequate as to space. The tents and other articles of this season's work had to be stored in the office. The necessary buildings ought to be constructed under the next appropriation.

ASTRONOMICAL STATION.

I would suggest that steps be taken to secure the astronomical determination, by the United States Coast and Geodetic Survey, of the position of some convenient point within the limits of the Park. No such determination now exists. I am informed by the Superintendent of the Coast Survey that he will be glad to coöperate with us for that purpose during the coming season. Some point on the shore of Yellowstone Lake near the outlet seems to me preferable. It is a central location and reduces to a minimum the triangulation necessary to determine the positions of the most eastern and most southern points of the lake on which the location of the east and south boundaries depends.

ROAD SPRINKLING.

The day before leaving St. Paul for the Park last spring I hastily collected, by your direction, such data as I could obtain in the short time available bearing on the ques-

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*Not printed.

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tion of sprinkling the Park roads. As you had indicated an intention of adopting some project for the above purpose, I gave considerable attention to the matter while in the Park during the past season, and since my return to this office I have collected as definite information as possible, in the absence of any direct experiment, as to the cost and practicability of the undertaking.

The results at which I have arrived are as follows:

I have assumed that any plan which may be offered will be expected to apply to the entire system of roads now open to travel. The system at present includes about 120 miles of road. The following data, supplied through the courtesy of Mr. George L. Wilson, assistant city engineer, and Mr. W. S. Young, sprinkling inspector, both of this city, furnish as close a criterion as can be readily obtained for our work:

One sprinkler travels in a day about 35,000 feet, or approximately 7 miles. The actual length of street sprinkled depends, of course, upon its width and the number of times it is sprinkled.

A 600-gallon tank, covering 16 feet of roadway, travels, according to the condition of the street, 1,200 to 1,500 feet without refilling.

Streets are springled in hot weather from three to five times per day.

Paved streets are sprinkled oftener than dirt streets.

Where the former are sprinkled four or five times per day, the latter are sprinkled three or four times.

Streets with steep grades require on an average one more sprinkling per day than streets approximately level.

The number of sprinklings also depends on the location of a street with reference to tall buildings, which may shut off the sunlight.

Sprinklers when full of water weigh about 8,000 pounds.

One team per sprinkler on paved streets is generally sufficient.

These data applied to roads of the Yellowstone National Park would be modified about as follows:

The length of roadway covered by a single sprinkler would probably fall considerably under the above figure (1) on account of steep grades and soft roads, and (2) on account of the greatly increased amount of time lost in filling sprinklers. I have assumed that the sprinklers will be restricted to twice per day. This, however, might prove quite insufficient. The nearest comparative data that I have been able to obtain is the amount of sprinkling required in the city of Helena, Mont. The average amount of water per square foot per day required there is one-half gallon. Two sprinklings per day, as above proposed, will give only about .06 gallons per square foot.

The width of roadway sprinkled will probably be reduced to about 8 feet.

A 600 gallon sprinkler will, therefore, cover one-half mile or less of road without refilling.

The number of horses required to pull a sprinkler full of water will be from four to eight, according to grade and quality of road.

From two-thirds to three-fourths of the total length of roadway is subject to the action of the sun during the entire day. The remainder of the road lies through forest or canyon, and may be compared to streets in thickly populated portions of a city.

A great portion of the Park roads are hilly, some of the hills being very steep.

Storage tanks must be located at least every half mile, with a strong probability, based upon the foregoing data, that they will be required as often as every third of a mile.

In a large proportion of cases the tanks will rest on the ground or be set in the ground on account of the difficulty of getting sufficient fall to fill an elevated tank. The filling of the sprinklers will, therefore, have to be accomplished in many cases by means of pumps, which will require the sprinklers to be equipped for that purpose. The filling in such cases will consume from one-half hour to one hour.

The facilities for filling storage tanks are not such as one would infer from general distribution of water in the Park. A careful consideration of the whole line of road indicates that for only about one-third of the distance can water be obtained for filling elevated tanks if it is not brought a greater average distance than 500 feet. Another third of the distance will supply water for surface tanks. The remaining third of the distance gives no indication, so far as I can remember, of any water supply whatever.

To properly sprinkle the roads twice per day will, therefore, require at least 40 sprinklers and 250 storage tanks.

To operate this plant will require one overseer, about 10 foremen, 40 drivers, and 100 teams, together with some provision for executing repairs. It may be found necessary to add laborers to assist in filling the sprinklers when this is done by means of pumps.

The plant should be throughout of the most thorough construction, for the service will be very severe.

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The cost of such a plant and its operation for one season will be approximately as follows:

Cost of plant:		
40 sprinklers complete, of best make, equipped with brake, pump, and facilities for attaching lead teams, and 250 storage tanks, each with 500 feet of 1-inch wrought-iron pipe, all delivered at Cinnabar, Mont.		$35,000
Transportation of plant from Cinnabar to Park		1,500
Cost of lumber, labor, and superintendence in setting up plant in Park.		7,500
Add 10 per cent contingencies		4,400
Total		48,400
Cost of operation:		
100 teams, at $3.66⅔ per day, and 40 drivers, at $2 per day, including board; daily expense	$446.66⅔	
Season from June 20 to September 20, makes 90 days, at $446.66⅔.	$40,200	
Superintendence	2,000	
Repairs, etc	1,500	
Proportion of office and other expenses	900	
		44,600
Total outlay for first season		93,000

I have no doubt that an actual trial of the experiment will show that, owing to exceptional causes already alluded to, the above figures will be found too small and that the expense will reach $100,000.

The sprinkling of the hill roads will be a serious matter. The progress up hill with so large a load will be very slow; it will be necessary to stop every few rods to rest the teams. This will make it difficult to regulate the flow properly and it will also very much lessen the length of roadway covered per day. It may be suggested to sprinkle only down hill, but this at once doubles the expense by necessitating a drive one way to no purpose. Moreover, on the steeper hills, it is improbable that if enough water be put on the roads to last four hours, it will most of it, reach the foot of the hill before the sprinkler does.

The running expense will have to be considered as a constant quantity, even when the roads may not need sprinkling. Teams could not be hired on the condition of losing all time when the roads are not dusty. And they could not otherwise be used to advantage. A driver with a four-horse team and a wagon, but without other assistance, is not in shape to do effective work, while a concentration of teams would be quite out of the question. Every opportunity, such as rainy weather, would be taken by the drivers to get to a blacksmith or repair shop for shoeing horses and making repairs.

It may be accepted as reasonably certain that a first-class sprinkling plant for the existing system of roads in the National Park and its operation for one year will cost a sum at least one-third greater than any single appropriation which the Park has yet received.

The undertaking appears to me, in view of the limited appropriations, wholly impracticable. Furthermore, if an appropriation were available large enough to leave a considerable sum for this purpose, it would not, in my opinion, be advisable to so expend it. The terribly dusty state of the roads in dry weather is very largely due to the fact that they are composed of nothing but the ordinary soil through which the roadway passes, in the general case utterly worthless for road material. It becomes mire in wet weather; in dry weather, powder. The remedy lies, not in sprinkling this powder, but in getting rid of it. The cost of a sprinkling plant and its operation in one season would cover with good gravel, as recommended in this report, 40 miles of road. This would suppress dust and mud at the same time.

If, however, it is decided to try the experiment, I would strongly recommend that it might be done for one season on a very limited scale. Two sprinklers might be put on the road from Gardiner River to the top of Golden Gate Hill, a distance of about 28,000 feet. Owing to the large amount of steep grade on this stretch, there would probably be needed about fourteen supply tanks. Each sprinkler would require a six or eight horse team. If the experiment can be made a success here, it can anywhere in the Park. The road is one of the dustiest and it is a good place to commence. Being near the engineer office, it would thus facilitate the work of collecting data for future use. The cost will be approximately $5,000.

If, after one season's trial, the scheme proves a failure, we shall not be encumbered with an extensive and useless plant. If it proves a success, our additional information will enable us to prepare more exact specifications for a complete plant.

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CAPTAIN KINGMAN'S REPORT.

In my opinion, steps ought to be taken to secure the publication, by the Chief of Engineers, of the reports of Captain Kingman's work in the Park. These reports, extending over three years, have never been published by either the Chief of Engineers, Secretary of War, or the Interior Department. In answer to a letter of inquiry to Captain Kingman in relation to this matter he says that the Secretary of War directed "that I should make my report to him. I did so in those years, sending the reports through the Chief of Engineers. The reports going to the Chief of Engineers in this exceptional way were of course not regarded by him as proper subjects for his annual report. He furnished from his office a copy to the Interior Department, but somehow between them all the reports have never been printed."

Captain Kingman was the first officer of the Corps of Engineers placed in charge of the improvement of the Yellowstone National Park. The project he adopted and the general rules laid down in regard to road work there have been closely followed by his successors. His reports cover nearly all subjects of engineering interest in connection with that work, and time has, in nearly every instance, shown the correctness of his views. The reports are, therefore, of especial value, not only for their intrinsic merit, but also by reason of their being the only source of information on the first three years of the work.

The only place where they can now be found, so far as I am aware, is in manuscript form in this office.

In concluding this report, I desire to express my thanks to the superintendent of the Park and the officers stationed there for their frequent material assistance in the prosecution of the season's work.

Very respectfully, your obedient servant,

HIRAM M. CHITTENDEN,
First Lieut., Corps of Engineers.

Maj. W. A. JONES,
Corps of Engineers, St. Paul, Minn.

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APPENDIX E E E.

EXPLORATIONS AND SURVEYS IN MILITARY DEPARTMENTS.

E E E 1.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE MISSOURI.

ANNUAL REPORT OF LIEUTENANT CASSIUS E. GILLETTE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

ENGINEER OFFICE,
HEADQUARTERS DEPARTMENT OF THE MISSOURI,
Chicago, Ill., July 20, 1892.

SIR: I have the honor to submit the following report as engineer officer of this department for the year ending June 30, 1892.

Previous to April 21, 1892, the office was in charge of Capt. William L. Marshall, Corps of Engineers.

No field work has been done during the year.

The office force has consisted of one general service clerk, Frederick A. Petersen.

The office work has consisted in the preparation of maps, tracings, reproductions, etc., for use of the department commander and other officers connected with department headquarters.

During the year there have been prepared 11 maps and 9 other original drawings, 20 tracings, and 1,320 other reproductions. Nineteen maps have been mounted.

The most important of the above have been in connection with the campaign against hostile Sioux of Dakota, 1890–'91.

Very respectfully, your obedient servant,

CASSIUS E. GILLETTE,
First Lieut., Corps of Engineers,
Engineer Officer, Dept. Missouri.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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E E E 2.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE COLUMBIA.

REPORT OF MAJOR TULLY M'CREA, FIFTH UNITED STATES ARTILLERY, FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

ENGINEER OFFICE,
HEADQUARTERS DEPARTMENT OF THE COLUMBIA,
Vancouver Barracks, Wash., July 1, 1892.

SIR: I have the honor to submit the following report of the operations of this office for the fiscal year ending June 30, 1892.

I entered upon the duties of this office September 4, 1891, in compliance with General Orders, No. 17, Headquarters Department of the Columbia, August 18, 1891, relieving the acting engineer officer, Capt. Charles H. Clark, Ordnance Department.

FIELD WORK.

Lines of levels upon the Vancouver Military Reservation in connection with proposed extension of sewerage system.

Surveys rendered necessary by changes and improvements at Vancouver Barracks.

OFFICE WORK.

The office work included the preparation of plans, profiles, and reports based upon the surveys referred to above; the revision of the progress sheets of the department map from the latest Land-Office maps and other data; the preparation of maps showing new roads, railroads, towns, post-offices, etc., to facilitate the publication of a new edition of the military map of this department; various reports in relation to matters referred to this office for information and action; map-drawing, tracing, solar printing, map-mounting, and other routine work pertaining to this office.

Maps, plans, and profiles drawn by hand	16
Tracings for issue and office files	10
Solar prints	160
Negatives for official use	7
Maps mounted on linen	72
Department maps issued	40

PERSONNEL.

General Service Clerk N. de G. Dion was on duty in this office from date of last report until July 10, 1891, when he was discharged under the authority of paragraph 158, Army Regulations.

General Service Clerk Charles A. Homan was assigned to duty as topographical assistant and draftsman in this office August 7, 1891. There has been no other office force.

Standard time has been furnished to the post by signal throughout the year.

This office has been without funds during the entire year. Drawing and such other materials as were absolutely necessary to carry on the regular work of this office have been furnished from time to time by the Quartermaster's Department.

Very respectfully, your obedient servant,

TULLY MCCREA,
Major, Fifth Artillery, Acting Engineer Officer.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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E E E 3.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE PLATTE.

REPORT OF CAPTAIN CHARLES A. WORDEN, SEVENTH INFANTRY, FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

ENGINEER OFFICE,
HEADQUARTERS DEPARTMENT OF THE PLATTE,
Omaha, Nebr., July 5, 1892.

SIR: I have the honor to submit my annual report as acting engineer officer of the Department of the Platte for the fiscal year ending June 30, 1892.

October 21, 1891, by order of the department commander, I surveyed the northern, eastern, and southern boundary lines of the Fort Omaha military reservation.

Work has been continued on the compilation of the map of this department east of the one hundred and third meridian, which will be completed for reproduction and publication in the course of a few weeks.

Engineering instruments have been received from the commanding officer of Willets Point Engineer Depot.

Instruments, notebooks, maps, tracings, and blue prints have been supplied to the various posts from time to time whenever requested.

Several maps of this department west of the one hundred and third meridian have been issued to the officers in the field in Wyoming, on which were marked the counties, recently constructed railroads, etc.

Large-scale blue-print maps of northeastern Wyoming, showing the location of all the cattle ranches and other points of importance, have been issued to the troops in the field.

Very respectfully, your obedient servant,

CHAS. A. WORDEN,
Captain, Seventh Infantry, Acting Engineer Officer.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

E E E 4.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF CALIFORNIA.

ANNUAL REPORT OF LIEUTENANT CHARLES G. LYMAN, SECOND CAVALRY, A. D. C., FOR THE FISCAL YEAR ENDING JUNE 30, 1892.

ENGINEER OFFICE,
HEADQUARTERS DEPARTMENT OF CALIFORNIA,
San Francisco, Cal., June 30, 1892.

SIR: I have the honor to submit the following report of operations of this office for the fiscal year ending June 30, 1892.

From the close of the last fiscal year to April 3, 1892, this office was in charge of First Lieut. James E. Runcie, First Artillery, acting engineer officer, who on that day was relieved from duty at these headquarters, and turned over the property belonging thereto to First. Lieut. Leonard A. Lovering, Fourth Infantry, Aide de Camp, under Special Orders No. 35, dated Headquarters Department of California, April 2, 1892.

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By virtue of Special Orders No. 53, dated Headquarters Department of California, May 16, 1892, I relieved Lieut. Lovering and took charge of the office.

Assistant C. Winstanley, general service clerk, has been continually on duty as topographer and draftsman.

The office work has involved the preparation of original drawings, tracings, and blue prints of maps, etc., for use at these headquarters and the posts in the department, the distribution of maps, and the care and preservation of the surveying and other instruments in store.

Maps have been prepared, colored, and mounted, to supply the different offices at these headquarters, and such assistance as has been called for by officers at posts has been rendered. Instruments have been furnished for use at the different posts and to the Quartermaster's Department, when required.

No field work of any importance has been entered into during the year.

Very respectfully, your obedient servant,

CHAS. G. LYMAN,
Second Lieutenant, Second Cavalry, A. D. C., in charge of office.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

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LAWS

AFFECTING

THE CORPS OF ENGINEERS,

UNITED STATES ARMY.

FIFTY-SECOND CONGRESS, FIRST SESSION.

1891-'92.

3461

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LAWS

AFFECTING

THE CORPS OF ENGINEERS, UNITED STATES ARMY.

FIFTY-SECOND CONGRESS, FIRST SESSION, 1891-'92.

PUBLIC ACTS.

CHAP. 8.—An act to amend an act entitled "An act for the construction of a railroad and wagon bridge across the Mississippi River at South Saint Paul, Minnesota", approved April twenty-six, eighteen hundred and ninety.

February 15, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the act entitled "An act for the construction of a railroad and wagon bridge across the Mississippi River at South Saint Paul, Minnesota," approved April twenty-six, eighteen hundred and ninety, as amended by an act entitled "An act to amend an act entitled 'An act for the construction of a bridge at South Saint Paul, Minnesota,'" approved February twenty-fourth, eighteen hundred and ninety-one, be, and hereby is, amended as follows:

South Saint Paul Railroad Company bridge over Mississippi River, South Saint Paul. Minn.

Vol. 26, pp. 69, 788.

First, by striking out section one of said bill as amended and substituting in lieu thereof the following:

"That the South Saint Paul Belt Railroad Company, its successors and assigns, be, and they are hereby, authorized to construct and maintain, at a point suitable to the interest of navigation, a railroad bridge, or a combined railroad, wagon, and foot passenger bridge, across the Mississippi River from a suitable point on its west bank, at or near the city of South Saint Paul, in the State of Minnesota, and within the limits of section two, township twenty-seven, range twenty-two west, to a corresponding point on its east bank, and to lay on or over said bridge a railroad track or tracks for the more perfect connection of any railroad or railroads that are or shall be constructed to said river, on either or both sides thereof, at or opposite said places, under the limitations and conditions hereinafter provided; that said bridge shall not interfere with the free navigation of said river beyond what is necessary to carry into effect the rights and privileges hereby granted; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, or damage resulting from the same, the cause may be tried before the circuit court of the United States in and for any district in which any portion of said bridge or obstruction touches; said bridge may, at the option of the company building the same, be constructed to provide for the passage of railroad trains alone, or for the passage of railroad trains and for the safe passage of wagons and vehicles of all kinds, for the transit of animals and for foot passengers, all for such reasonable rates of toll as may be fixed from time to time by the Secretary of War."

Change of location authorized.

Location.

Litigation.

Railway, or railway, wagon, and foot bridge.

Tolls.

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Vol. 26, pp. 71, 788, amended.

Second, by striking out section seven of said bill and substituting in lieu thereof the following, to wit:

Time for construction extended.

"SEC. 7. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date of the approval of these amendments."

Approved, February 15, 1892.

March 29, 1892.

CHAP. 25.—An act to amend section twelve hundred and sixteen of the Revised Statutes, relative to certificates of merit to the enlisted men of the Army.

Army. Certificates of merit extended to all enlisted men. R. S., sec. 1216, p. 215, amended.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section twelve hundred and sixteen, Revised Statutes, be, and is hereby, amended to read:

"SEC. 1216. That when any enlisted man of the Army shall have distinguished himself in the service, the President may, at the recommendation of the commanding officer of the regiment or the chief of the corps to which such enlisted man belongs, grant him a certificate of merit."

Approved, March 29, 1892.

April 7, 1892.

CHAP. 38.—An act to amend an act entitled "An act to authorize the construction of a railroad, wagon, and foot-passenger bridge at Burlington, Iowa, approved August sixth, eighteen hundred and eighty-eight" as amended by act approved February twenty-first, eighteen hundred and ninety.

Burlington, Iowa. Time for constructing bridge at, extended. Vol. 25, p. 360; Vol. 26, p. 12.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time for the commencement and completion of said bridge, authorized by said act entitled "An act to authorize the construction of a railroad, wagon, and foot-passenger bridge at Burlington, Iowa, approved August sixth, eighteen hundred and eighty-eight," as amended by act approved February twenty-first, eighteen hundred and ninety, be, and is hereby, each extended two years from the passage of this act.

Approved, April 7, 1892.

April 15, 1892.

CHAP. 45.—An act to authorize the construction of a bridge across the Missouri River, between the city of Chamberlain, in Brulé County, and Lyman County, in the State of South Dakota.

Chamberlain Pontoon Bridge Company may bridge Missouri River at Chamberlain, S. Dak.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Chamberlain Pontoon Bridge Company, a corporation duly organized and existing under the laws of the State of South Dakota, be, and is hereby, authorized to construct and maintain a bridge and approaches thereto across the Missouri River between the city of Chamberlain, in the State of South Dakota, and Lyman County, in the State of South Dakota. Said bridge shall be constructed to provide for the passage of railroad trains, wagons, and vehicles of all kinds, steam and street cars, animals, foot passengers, and for all road travel, for such reasonable rates of toll and under such reasonable rules and regulations as may be prescribed by said corporation and approved by the Secretary of War, or said bridge may be constructed as a wagon and foot bridge alone.

Railway, wagon, and foot bridge.

Toll, etc.

May be wagon and foot bridge.

Lawful structure and post-route.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post route, upon which also no higher charge shall be

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made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroad or public highways leading to said bridge, and it shall enjoy the rights and privileges of other post roads in the United States; and an equal privilege in the use of said bridge shall be granted to all telegraph and telephone companies, and the United States shall have the right of way across said bridge and its approaches for postal telegraph purposes. Postal telegraph.

SEC. 3. That said bridge shall be constructed as a pontoon bridge, and shall contain a drawspan giving a clear opening of not less than three hundred feet in length, which drawspan shall be maintained over the main channel of the river at an accessible and navigable point, and said bridge other than the drawspan shall be at right angles to the current of the river at high water: *Provided*, That said draw shall be opened promptly by said company upon reasonable signal for the passage of boats and rafts, and said company or corporation shall maintain, at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe. No bridge shall be erected or maintained under the authority of this act which shall at any time unreasonably obstruct the free navigation of said river, and if any bridge erected under such authority shall, in the opinion of the Secretary of War, unreasonably obstruct such navigation, he is hereby authorized to cause the entire removal thereof or such change or alteration of said bridge to be made as will effectually obviate such obstruction, and all such alterations shall be made and all such obstructions shall be removed at the expense of the owner or owners of said bridge, and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, the case may be brought in the district court of the United States of the State of South Dakota in whose jurisdiction any portion of said obstruction or bridge may be located: *Provided further*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of the law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operations of the same. Construction. Drawspan. *Provisos.* Opening draw. Lights, etc. Unobstructed navigation. Litigation. Existing laws.

SEC. 4. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railroad trains or cars over the same and over the approaches to the same upon the payment of a reasonable compensation for such use, and in case the owner or owners of said bridge and the several railroad companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon the rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties. Use by railroads. Compensation. Disagreement. Decision by Secretary of War.

SEC. 5. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of the navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawing of the bridge and a map of the location, giving, for the space of one-half mile above and one-half mile below the proposed location, the high and low water lines upon the banks of the river, the direction and strength of the currents at low and at high water, with the soundings, accurately showing the bed of the stream, and the location of any other bridge or bridges, such map to be sufficiently in detail to enable the Secretary of War to judge of the proper location of said bridge, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject, and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be commenced or built, and should Secretary of War to approve plans, etc.

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Changes. any change be made in the plans of said bridge during the progress of its construction such changes shall be subject to the approval of the Secretary of War.

Commencement and completion. *Proviso.* Amendment, etc. SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date hereof: *Provided*, That Congress reserves the right to alter, amend, or repeal this act whenever the public interests so require.

Approved, April 15, 1892.

April 15, 1892.

CHAP. 46.—An act authorizing the Velasco Terminal Railway Company to construct a bridge across the Brazos River, in the State of Texas.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Velasco Terminal Railway Company, a corporation incorporated and organized under the laws of the State of Texas, and to its successors and assigns, to construct and maintain a bridge and approaches thereto across the Brazos River, in the State of Texas, between its mouth and a point twelve miles up said river. Said bridge shall be so constructed as to provide for the passage of railway trains, and, at the option of the said corporation, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals, and for foot passengers, for reasonable rates of toll, to be fixed by said company, and approved by the Secretary of War.

Velasco Terminal Railway Company may bridge Brazos River, Texas.

Railway, wagon, and foot bridge.

Tolls.

SEC. 2. That any bridge built under this act shall be constructed as a pivot drawbridge, with a draw over the main channel at an accessible and the best navigable point, and with spans giving a clear water way, measured at the lowest stage of water known at the locality, of such width and height as the Secretary of War may, upon examination, prescribe; and the lowest part of the superstructure of the bridge shall be of such elevation above the plane of the highest flood known at the locality as the Secretary of War may deem advisable; and the piers of said bridge shall be parallel to and the bridge shall be at right angles to the current of the river: *Provided*, That the draw shall be opened promptly upon reasonable signal for the passage of boats and other water craft, except when trains are passing over the draw; but in no case shall unnecessary delay occur in opening the draw during or after the passage of trains; and said corporation shall maintain at its own expense, from sunset to sunrise, such lights and other signals on said bridge as the Light-House Board shall prescribe, and said corporation shall provide at its own expense such sheer booms, guide piers, and other device as may be necessary to facilitate the safe passage of boats or other water craft through the spans of said bridge. The said bridge shall be located and built under and subject to such regulations for the security of the navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company shall submit to the Secretary of War, for his examination and approval, a design and drawings of said bridge and a map of the location, giving, for the space of one mile below and one mile above the proposed location, the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the current at all stages, and the soundings, accurately showing the bed and channel of the stream, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and until the said location and plans of the bridge hereby authorized to be constructed are approved by the Secretary of War, the said bridge shall not be commenced or built; and should any change be made in the plan of such bridge during the progress of construction thereof, such change shall be subject to the approval of the Secretary of War; and any alteration or changes that may be required by the Secre-

Construction.

Spans.

Piers.

Proviso.

Opening draw.

Lights, etc.

Location.

Secretary of War to approve plans, etc.

Changes.

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tary of War in the bridge constructed under this act shall be made by the corporation owning or controlling the same at its own expense; and in case of any litigation arising from the obstruction or alleged obstruction caused by said bridge to the free navigation of said river, the cause may be tried before the circuit court of the United States in whose jurisdiction any portion of the bridge is located. Litigation.

SEC. 3. That the bridge authorized to be constructed under this act shall be a lawful structure, and shall be recognized and known as a post route, upon which also no higher charge shall be made for the transmission over the same of the mails, troops, and the munitions of war of the United States, than the rate per mile paid for their transmission over the railroads leading to said bridge; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies; and the United States shall have the right of way across said bridge and its approaches for postal telegraph purposes. Lawful structure and post route. Postal telegraph.

SEC. 4. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same, and over the approaches thereto, upon payment of a reasonable compensation for such use: and in case the owner or owners of said bridge and the several railroad companies, or any of them, desiring such use, shall fail to agree upon the sum or sums to be paid and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties. Use by other railroad companies. Compensation. Disagreements. Secretary of War to decide.

SEC. 5. That the right to alter, amend, or repeal this act is hereby expressly reserved; and if said bridge shall not be commenced in one year and be finished within three years from the passage of this act, the rights and privileges hereby granted as to such bridge shall be null and void. Amendment, etc. Commencement and completion.

Approved, April 15, 1892.

CHAP. 49.—An act to amend an act entitled "An act to authorize the Oregon and Washington Bridge Company to construct and maintain a bridge across the Columbia River, between the State of Oregon and the State of Washington, and to establish it as a post road." April 18, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That "An act to authorize the Oregon and Washington Bridge Company to construct and maintain a bridge across the Columbia River, between the State of Oregon and the State of Washington, and to establish it as a post road," approved March twenty-fourth, eighteen hundred and ninety, be, and the same is hereby, extended, revived, and declared to be in full force and effect from and after March twenty-fourth, eighteen hundred and ninety-two. Section twelve of said act, which provides that said act shall be null and void if actual construction of the bridge therein authorized be not commenced within two years and completed within four years from date of the approval thereof, shall be, and the same is hereby, so amended that the time within which said bridge is required to be commenced shall be within one year from March twenty-fourth, eighteen hundred and ninety-two, and the time within which it is required that said bridge be completed shall be within three years from the twenty-fourth day of March, eighteen hundred and ninety-two. Oregon and Washington Bridge Company's bridge across Columbia River. Vol. 26, p. 25. Act revived. Time for construction extended. Vol. 26, p. 28. *Post*, p. 87.

Approved, April 18, 1892.

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May 9, 1892.

CHAP. 61.—An act authorizing the Leavenworth and Platte County Bridge Company to sell, transfer, and assign to the Leavenworth Terminal Railway and Bridge Company the rights and franchises as granted by acts of Congress approved February twenty-fifth and March second, eighteen hundred and eighty-nine, and by act of Congress approved July twenty-fifth, eighteen hundred and ninety.

Leavenworth and Platte County Bridge Company may sell its rights to bridge Missouri River, etc., to Leavenworth Terminal Railway and Bridge Company.

Vol. 25, pp. 691, 883.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That permission be, and is hereby, granted to the Leavenworth and Platte County Bridge Company, a corporation duly organized and existing under the laws of the State of Kansas, to sell, transfer, and assign to the Leavenworth Terminal Railway and Bridge Company, a corporation duly organized and existing under the laws of the State of Kansas, its successors and assigns, all of the rights and franchises granted to the said Leavenworth and Platte County Bridge Company by an act of Congress entitled "An act to authorize the construction of a bridge across the Missouri River between the city of Leavenworth, in the State of Kansas and Platte County, in the State of Missouri," approved February twenty-fifth, eighteen hundred and eighty-nine, and by an act of Congress entitled "An act to authorize the construction of a bridge across the Missouri River between the city of Leavenworth, in the State of Kansas and Platte County, in the State of Missouri," approved March second, eighteen hundred and eighty-nine, and by an act of Congress entitled "An act to authorize the Leavenworth and Platte County Bridge Company to substitute a pivot drawbridge over the Missouri River in place of a pontoon bridge," approved July twenty-fifth, eighteen hundred and ninety; and any such transfer and conveyance as has been heretofore made is hereby consented to and confirmed: *Provided, however*, That the conditions, limitations, and restrictions imposed by existing law upon the said Leavenworth and Platte County Bridge Company shall continue in force as to the said Leavenworth Terminal Railway and Bridge Company.

Vol. 26, p. 291.

Proviso.

Conditions, etc., continued.

Approved, May 9, 1892.

May 12, 1892.

CHAP. 68.—An act to authorize the construction of a bridge across the Missouri River at De Witt, Carroll County, Missouri, and to establish it as a post road.

Brookfield and Northern Railroad Company may bridge Missouri River at De Witt, Mo.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Brookfield and Northern Railroad Company, a corporation organized under the laws of the State of Missouri, or its successors or assigns, to construct a bridge across the Missouri River at a point opposite, or as nearly opposite as may be, to the town of De Witt, in the county of Carroll and State of Missouri; that said bridge may be constructed for railway, wagon, and postal service, with single or double track for railway traffic, and which shall be under the conditions and limitations hereinafter specified.

Railway and wagon bridge.

Unobstructed navigation.

SEC. 2. That said bridge shall not interfere with the free navigation of said river beyond what may be necessary to carry into effect the rights and privileges herein granted, and in case of any litigation arising under the provisions of this act such litigation may be tried and determined by the circuit court of the United States within whose jurisdiction said bridge is located.

Litigation.

Construction.

Spans.

SEC. 3. That the bridge hereby authorized to be constructed must be constructed as a high bridge, with unbroken and continuous spans, all spans over the water way to have a clear channel way of not less than four hundred feet and a clear head room of not less than fifty-five feet above high water mark.

Lawful structure, and post route.

SEC. 4. That any bridge constructed under this act shall be a lawful structure and shall be known as a post road, and the same is hereby declared to be a post road, over which no higher charge shall be made for the transmission of mails, troops, and munitions of war of the Government of the United States or for passenger or freight passing over the same than the rate per mile charged for their transportation over the railroad or public highways leading to the said bridge, and equal privileges in the use of said bridge

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shall be granted to all telegraph and telephone companies. The United States shall have also the right of way over said bridge for postal-telegraph purposes.

Postal telegraph.

SEC. 5. That all railway companies desiring to use said bridge shall be entitled to equal rights and privilges in using the same, including the machinery and fixtures thereto belonging, and also the approaches thereto, upon such terms and conditions as shall be prescribed by the Secretary of War upon hearing the allegations and proofs of the parties in interest, in case the parties in interest shall not be able to agree upon such terms and conditions.

Use by other companies.

Terms.

SEC. 6. That the said railway company, before entering upon the construction of said bridge, shall submit to the Secretary of War plans and drawings of said structure, together with a map of the location thereof for one mile above and one mile below said location, giving the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the current of said river at all stages of the water, showing also the bed of the river and the channel, with such other and further information as the Secretary of War may require; which said drawings and other information aforesaid shall be examined by him, and if he shall approve the same he shall so notify the said railway company of such approval, and thereupon said company may proceed to the erection of said bridge. The Secretary of War may make such alterations in such plans as he may deem necessary to the better protection of navigation, and such alterations shall be adopted and paid for by the said railway company or its successors and assigns. The said railway company may at any time make any alterations deemed advisable to be made in said bridge, but must first submit such proposed alterations to the Secretary of War, and his approval shall be first had before they shall be made.

Secretary of War to approve plans, etc.

Alterations.

SEC. 7. That the said bridge herein authorized to be constructed shall be so kept and managed at all times as to afford proper means and ways for the passage of vessels, barges, or rafts under it both by day and night. There shall be displayed on said bridge from sunset to sunrise such lights and signals as may be directed by the Light-House Board, and such changes may be made from time to time in the structure of said bridge as the Secretary of War may direct, at the expense of said company or its successors and assigns, in order the more effectually to preserve the free navigation of said river, or the said structure shall be altogether removed, if in the judgment of the Secretary of War the public good may require such removal, and without expense or charge to the United States.

Aids to navigation.

Lights, etc.

SEC. 8. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within two years and completed within four years from the date of the approval of this act.

Commencement and completion.

SEC. 9. That the right to alter, amend, or repeal this act is hereby specially reserved.

Amendment, etc.

Approved. May 12, 1892.

CHAP. 69.—An act to authorize the construction of a bridge across the Osage River, between the town of Warsaw and the mouth of Turkey Creek, in Benton County, Missouri.

May 12, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Springfield, Sedalia, Marshall and Northern Railroad Company, a corporation organized under the laws of the State of Missouri, or its successors or assigns, to construct a bridge across the Osage River at a point between the town of Warsaw and the mouth of Turkey Creek, in the county of Benton and State of Missouri; that said bridge may be constructed for railway, wagon, and postal service, with single or double track for railway traffic, and which shall be under the conditions and limitations hereinafter specified.

Springfield, Sedalia, Marshall and Northern Railroad Company may bridge Osage River between Warsaw and mouth of Turkey Creek, Mo.

Railway and wagon bridge.

SEC. 2. That said bridge shall not interfere with the free navigation of said river beyond what may be necessary to carry into effect the rights and privileges herein granted, and in case of any

Unobstructed navigation.

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Litigation. litigation arising under the provisions of this act such litigation may be tried and determined by the circuit court of the United States within whose jurisdiction said bridge is located.

Construction. Spans. SEC. 3. That the bridge hereby authorized to be constructed must be constructed as a high bridge, with unbroken and continuous spans, having at least one channel span of not less than four hundred feet clear channel way and all other spans over the water way to have a clear channel way of not less than three hundred feet, and all spans shall have a clear headroom of not less than fifty feet above high-water mark.

Lawful structure and post route. SEC. 4. That any bridge constructed under this act shall be a lawful structure and shall be known as a post road, and the same is hereby declared to be a post road, over which no higher charge shall be made for the transmission of mails, troops, and munitions of war of the Government of the United States or for passengers or freight passing over the same than the rate per mile charged for their transportation over the rail road or public highways leading to the said bridge; and equal privileges in the use of said bridge shall be granted to all telegraph companies. The United States shall have also the right of way over said bridge for postal-telegraph purposes.

Postal telegraph.

Use by other companies. SEC. 5. That all railway companies desiring to use said bridge shall be entitled to equal rights and privileges in using the same, including the machinery and fixtures thereto belonging, and also the approaches thereto, upon such terms and conditions as shall be prescribed by the Secretary of war upon hearing the allegations and proofs of the parties in interest, in case the parties in interest shall not be able to agree upon such terms and conditions.

Terms.

Secretary of War to approve plans, etc. SEC. 6. That the said railway company before entering upon the construction of said bridge, shall submit to the Secretary of War plans and drawings of said structure, together with a map of the location thereof for one mile above and one mile below said location, giving the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the current of said river at all stages of the water, showing also the bed of the river and the channel, with such other and further information as the Secretary of War may require; which said drawings and other information aforesaid shall be examined by him, and if he shall approve the same he shall so notify the said railway company of such approval; and thereupon said company may proceed to the erection of said bridge. The Secretary of War may make such alterations in such plans as he may deem necessary to the better protection of navigation, and such alterations shall be adopted by the said railway company. The said railway company may at any time make any alterations deemed advisable to be made in said bridge, but must first submit such proposed alterations to the Secretary of War, and his approval shall be first had before they shall be authorized or made.

Alterations.

Aids to navigation. Lights, etc. SEC. 7. That the said bridge herein authorized to be constructed shall be so kept and managed, at all times, as to afford proper means and ways for the passage of vessels, barges, or rafts under it both by day and night. There shall be displayed on said bridge, from sunset to sunrise, such lights and signals as may be directed by the Light-House Board, and such changes may be made from time to time in the structure of said bridge as the Secretary of War may direct, at the expense of said railway, in order the more effectually to preserve the free navigation of said river, or the said structure shall be altogether removed if in the judgment of the Secretary of War the public good may require such removal, and without expense or charge to the United States.

Commencement and completion. SEC. 8. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date thereof.

Amendment, etc. SEC. 9. That the right to alter, amend, or repeal this act is hereby especially reserved.

Approved, May 12, 1892.

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CHAP. 76.—An act authorizing the construction of a wagon and motor bridge over the Missouri River at Saint Charles, Missouri.

May 23, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Occidental Bridge and Construction Company, duly incorporated under the laws of Missouri, is hereby, authorized to construct and maintain a bridge, and approaches thereto, across the Missouri River, between the city of Saint Charles, Missouri, and Saint Louis County, Missouri, at a point at least one-third of a mile from any other bridge, to be selected consistent with the interests of river navigation. Said bridge shall be constructed to provide for the passage of wagons and vehicles of all kinds, street railway cars, motor cars, animals, foot passengers, and for all road travel for such reasonable rates of toll and under such reasonable rules and regulations as may be prescribed by its said company, and to be approved from time to time by the Secretary of War: *Provided*, That the said company, or its successors and assigns, shall build and maintain at all times, as accessory works to said bridge, such booms, piers, dikes, guard fences, and similar devices as may be necessary, in the judgment of the Secretary of War, to insure at all times a permanent channel for a sufficient distance above and below the bridge site, and for the guiding of rafts, steamboats, and other water craft safely under said bridge: *Provided further*, That the said company, or its successors and assigns, shall maintain on said bridge, from sunset to sunrise, such lights and other signals as the Light-House Board shall prescribe.

Occidental Bridge and Construction Company may bridge Missouri River at Saint Charles, Mo.

Street railway, etc., bridge.

Toll.

Provisos.
Aids to navigation.

Lights, etc.

SEC. 2. That said bridge shall not be built or commenced until the plan and specifications for its construction have been submitted to the Secretary of War for his approval, nor until he shall approve the plan and location of said bridge and accessory works: and if any change be made in the plan of construction of said bridge and accessory works at any time, such change shall be subject to the approval of the Secretary of War; and any change in the construction or any alteration of said bridge and accessory works that may be directed at any time by Congress or the Secretary of War shall be made at the cost and expense of the said company or its successors and assigns; that the said bridge shall be constructed without interference with the security and convenience of navigation of said river beyond what is necessary to carry into effect the rights and privileges hereby granted, and in order to secure that object the said company, or its successors and assigns, shall submit to the Secretary of War, for his examination and approval, a design and drawing of said bridge and accessory works and a map of the proposed location, giving for the space of one mile above and one mile below such proposed location the topography of the banks of the river, with shore lines and soundings, and such other information as may be required for a full understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the construction of said bridge shall not be commenced.

Secretary of War to approve plans, etc.

Unobstructed navigation.

SEC. 3. That said bridge shall be built as a high bridge with unbroken and continuous spans, all spans over the waterway to have a clear channel way of not less than four hundred feet, and a clear headroom of not less than fifty-five feet above high water mark; and the piers of said bridge shall be parallel with the current of said river, and the bridge itself at right angles thereto.

Spans.

SEC. 4. That the Secretary of War is hereby authorized and directed upon receiving such plan and other information, and upon being satisfied that a bridge so built will conform to the requirements of this act, to notify the company authorized to build the same that he approves of the same: and upon receiving such notification the said company may proceed to erect said bridge, conforming strictly to the approved plan and location, and should any change be made in the plan of the bridge or accessory works during the progress of the work thereon, such change shall be subject likewise to the approval of the Secretary of War.

Work to commence upon approval of plans, etc.

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Lawful structure and post route.

SEC. 5. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the street railways or public highways leading to the said bridge, and it shall enjoy the rights and privileges of other post roads in the United States; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies, and the United States shall hava the right of way across said bridge and its approaches for postal telegraph purposes.

Postal telegraph.

Commencement and completion.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date thereof.

Amendment, etc.

SEC. 7. That this act shall take effect and be in force from and after its passage; and the right to alter, amend, or repeal this act is hereby expressly reserved.

Approved, May 23, 1892.

June 6, 1892.

CHAP. 90.—An act to establish a railway bridge across the Illinois River, between a point at or near the city of Havana, in Mason County, and a point on the opposite side of said river, in Fulton County, in the State of Illinois.

Chicago, Peoria, and Saint Louis Railway Company may bridge Illinois River at Havana, Ill.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Chicago, Peoria and Saint Louis Railway Company, a corporation organized under the laws of the State of Illinois, its successors and assigns, are hereby authorized and empowered to erect, establish, and maintain a railway bridge across the Illinois River, between a point to be by them selected at or near the city of Havana, in Mason County, and a point to be selected by them on the opposite side of said river, in Fulton County, in the State of Illinois; and that said bridge shall not interfere with the free navigation of said river, and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, the same shall be instituted and determined in the district court of the United States for the southern district of the State of Illinois.

Free navigation.

Litigation.

Construction.

SEC. 2. That any bridge built under the provisions of this act may, at the option of the company building the same, be built as a drawbridge, with a pivot or other form of draw, or with unbroken or continuous spans: *Provided*, That if the said bridge shall be built with unbroken or continuous spans it shall have one or more channel spans, each having not less than three hundred and fifty feet clear channel way, measured normal to the current of said river, and not less than fifty-five feet clear headroom above high-water mark, and the clear headroom under the other channel spans may be less than fifty-five feet: *Provided*, That no part of the superstructure of such spans shall give a less headroom than ten feet above high-water mark: *And provided further*, That the interests of navigation be not injured by such reduction in height: and the piers of said bridge shall be parallel with the current of said river, and the main span shall be over the main channel of the river, and not less than three hundred and fifty feet in length: *And provided also*, That if any bridge built under this act shall be constructed as a drawbridge, the same shall be constructed as a pivot drawbridge, with a draw over the main channel of the river at an accessible and navigable point and with spans of not less than one hundred and sixty feet in length, measured normal to the current of said river, on each side of the central or pivot pier of the draw; and the next adjoining spans to the draw shall not be less than two hundred and fifty feet in length, measured normal to the current of said river, and every part of the superstructure shall give a clear headroom of not less than ten feet above high-water mark: *Pro-*

Provisos.

Spans.

Height.

Piers.

Draw.

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vided, That the spans of both high and low bridges shall be so located as to afford the greatest possible accommodations to the river traffic, and a draw-opening of low bridges shall, if practicable, be located next or near shore; and the piers of said bridge shall be parallel with the current of the river when said bridge may be erected: *And provided also*, That said draw shall be opened promptly upon reasonable signal for the passage of boats: *And provided also*, That if the approaches by land to said bridge shall be built over land submerged at high water, said approaches shall be provided with sufficient passages for water, in connection with the water way through the spans of said bridge, to pass the flood discharge of the Illinois River without unduly increasing the velocity of flow through the navigated spans of said bridge: *And provided also*, That all such dikes, booms, piers, fences, wing dams, and other accessory works, that may be necessary to safely guide all steamboats, rafts, tows, and other water craft navigating said river, up to and through said draw or channel spans at any and all stages of water in the Illinois River, within a distance of one mile above and one-half mile below said bridge shall be located, constructed, and maintained at all times as may be required by the Secretary of War: *And provided also*, That the approaches of said bridge by land or by water within the limits of high water with limiting and level lines of the natural surface, grades of track, and proposed high-water discharge openings, within said overflowed limits along the line of such road or any road using said bridge, and all accessory works herein required among other data hereinafter required shall be indicated, shown, and located upon the maps and plans of said bridge, hereinafter required to be submitted for approval to the Secretary of War.

Location of spans.

Opening draw.

Approaches.

Aids to navigation.

Data to be submitted.

SEC. 3. That any bridge constructed under this act and according to its limitation shall be a lawful structure, and shall be known and recognized as a post route, and the same is hereby declared to be a post route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for their transportation over the railroads and public highways leading to the said bridge, and the United States shall have the right of way for a postal telegraph across said bridge.

Lawful structure and post route.

Postal telegraph.

SEC. 4. That all railway companies desiring to use said bridge shall have and be entitled to equal rights and privileges in the passage of the same and in the use of the machinery and fixtures thereof, and of the approaches thereto, under and upon such terms and conditions as shall be prescribed by the Secretary of War upon hearing the allegations and proofs of the parties in case they shall not agree.

Use by other companies.

Terms.

SEC. 5. That the structure herein authorized shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of said bridge and approaches by land and by water and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the current at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge and approaches thereto are approved by the Secretary of War the bridge shall not be commenced or built, and should any change be made in the plan of said bridge during the process of construction such change shall be subject to the approval of the Secretary of War; and the said structure shall be at all times so managed and kept as to offer reasonable and proper means for the passage of vessels through or under said structure; and to secure the safe passage of vessels at night there shall be displayed on said

Secretary of War to approve plans, etc.

Changes.

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Lights.

bridge, from the hour of sunset to that of sunrise, such lights as may be prescribed by the Light-House Board: and the said structure shall be changed, at the cost and expense of the owners thereof, from time to time, as the Secretary of War may direct, so as to preserve the free and convenient navigation of said river.

Commencement and completion.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date thereof.

Amendment, etc.

SEC. 7. That the right to alter, amend, or repeal this act is hereby expressly reserved.

Approved, June 6, 1892.

June 6, 1892.

CHAP. 92.—An act granting to the Topeka Water and Electric Power Company of Kansas the right to erect and maintain a dam or dams across the Kansas River, within Shawnee County, in the State of Kansas.

Topeka Water and Electric Power Company may dam Kansas River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Topeka Water and Electric Power Company, a corporation created and organized under the laws of Kansas, its successors and assigns, to erect, construct, and maintain a dam or dams across the Kansas River at any suitable place or places within Shawnee County, in the State of Kansas.

Amendment etc.

SEC. 2. That the right to alter, amend, or repeal this act is hereby expressly reserved.

Approved, June 6, 1892.

June 6, 1882.

CHAP. 93.—An act to authorize building a bridge over Tennessee River.

Saint Louis and Birmingham Railway Company may bridge Tennessee River at Clifton, Tenn.

Railway, etc., bridge.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Saint Louis and Birmingham Railway Company, a corporation created and organized under the laws of the State of Tennessee, be, and is hereby, authorized to construct and maintain, for the purpose of running railway trains, also for passage of all kinds of road vehicles, wagons, carts, and conveyances for passengers, and for foot passengers, if said railroad company may desire to so do a bridge over the Tennessee River at a point on said river known as Clifton, in Wayne County, in the State of Tennessee or within two miles either above or below said point as said company may determine.

Lawful structure and post route.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure and shall be recognized and known as a post-route, upon which no higher charge shall be made for the transmission over the same of the mails, troops, and the munitions of war of the United States passing over said bridge than the rate per mile paid for transportation over the railroad leading to said bridge; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies, and it shall enjoy the rights and privileges of other post roads in the United States.

Drawbridge.

Proviso.

Span.

Opening draw.

SEC. 3. That the bridge built under this act shall be constructed as a pivot drawbridge, with a draw over the main channel of the river at an accessible and best navigable point, and with spans not less than one hundred and sixty feet in length in the clear at low water mark on each side of the channel or pivot pier of the draw, and said span shall not be less than ten feet above extreme high-water mark, measuring to the lowest part of the superstructure of the bridge; and the piers of said bridge shall be parallel to and the bridge itself at right angles to the current of the river at the average stage of water where said bridge may be erected: *Provided also,* That in said bridge there shall be one span of not less than three hundred feet in length in the clear at low water mark; that said draw shall be opened promptly by said company, upon reasonable signal, for the passage of boats or vessels, and said corporation

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shall maintain, at its own expense, from sunset to sunrise, such lights or other signals as the Light-House Board shall prescribe. Lights, etc.

SEC. 4. That no bridge shall be erected or maintained under the authority of this act which shall at any time substantially or materially obstruct the free navigation of said river, and if any bridge erected under such authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction, and all such alterations shall be made and all such obstructions be removed at the expense of the owner of said bridge. And in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, the case shall be brought in the district court of the United States, of the State of Tennessee, in which any portion of said obstruction or bridge may be located. Unobstructed navigation. Litigation.

SEC. 5. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulation for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War for his examination and approval a design and drawing of said bridge, and a map of the location, giving, for the space of two miles above and two miles below the proposed location, the topography of the banks of the river, the shore lines at high and low water, the directions and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be built; and should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War. Secretary of War to approve plans, etc. Changes.

SEC. 6. That all railroad companies desiring the use of any bridge constructed under this act shall have and be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same and over the approaches thereto upon payment of reasonable compensation for such use; and in case the owner or owners of said bridge, and the several railroad companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proof of the parties. Use by other companies. Terms.

SEC. 7. That it shall not be obligatory on said company in constructing said rairoad bridge to so construct the same for the passage of road vehicles or foot passengers, but may, as in this act provided, construct the same only as a railroad bridge if said company so decides; but in case the said bridge is constructed for the passage of common road vehicles and foot passengers, said company shall have no right to charge tolls on the same for a longer period than fifteen years, and then the same for such travel shall be free. But in charging tolls, no charge shall be in excess of the amounts here stated, to wit: Footmen, five cents each; single horse conveyance, including conveyances for people, twenty cents each; double-horse conveyances, thirty cents; four-horse conveyances, drawn by horses or oxen, fifty cents; horses with riders, ten cents; horses and cattle loose or led, six cents each; sheep and hogs, four cents each; turkeys, one cent each. May be only railway bridge. Tolls.

SEC. 8. That the right to alter, amend, or repeal this act is hereby expressly reserved, without any liability of the United States for damages on account of the alterations, amendments, or repeal of this act. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed in three years from date hereof. Amendment, etc. Commencement and completion.

Approved, June 6, 1892.

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June 8, 1892.

CHAP. 108.—An act to authorize the Illinois and Iowa Railway and Terminal Company to build a bridge across the Mississippi River at Moline, Illinois.

Illinois and Iowa Railway and Terminal Company may bridge Mississippi River at Moline, Ill.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Illinois and Iowa Railway and Terminal Company, a corporation duly created and existing under the laws of the State of Iowa, its successors or assigns, be, and they are hereby, authorized to construct and maintain a bridge and approaches thereto over the Mississippi River from a point at or near the eastern boundary of the city of Moline, in the county of Rock Island, in the State of Illinois, to the opposite shore of said river in the State of Iowa: *Provided*, That a location is found within such limits suitable to the interests of navigation. Said bridge shall be constructed to provide for the passage of railway trains, and at the option of said corporation, its successors or assigns, may be so constructed to provide for and be used also for the passage of wagons and vehicles of all kinds, for the transit of animals, and for foot passengers for reasonable rates of toll to be fixed by said corporation, its successors or assigns; and the Secretary of War shall have the right, from time to time, to revise, prescribe and determine such rates of toll.

Proviso.
Location.
Railway, etc., bridge.
Tolls.
Construction.

SEC. 2. That any bridge built under the provisions of this act may, at the option of the said company building the same, be built as a drawbridge or with unbroken, continuous spans: *Provided*, That if said bridge shall be constructed as a drawbridge, the same shall be constructed as a pivot drawbridge, with a draw over the main channel of the river at an accessible and navigable point, and with spans giving a clear width of water way of not less than two hundred feet on each side of the central or pivot pier of the draw, and the next adjoining span or spans to the draw shall give a clear width of water way of not less than three hundred and fifty feet, and every part of the structure shall give a clear head room of not less than ten feet above extreme high-water mark: *Provided*, That all spans shall be so located as to afford the greatest possible accommodations to the river traffic, and a draw shall be, if practicable, as near the shore as the deepest water way will permit: *Provided, also*, That in case of a low bridge, if the physical characteristics so require, and the interests of navigation be not injured thereby, the length of the fixed spans may be reduced: *Provided further*, That the piers of said bridge shall be parallel with the current of the river where said bridge shall be erected: *And provided also*, That said draw shall be opened promptly, upon reasonable signal, for the passage of boats, except when trains are passing over the draw; but in no case shall unnecessary delay occur in opening the said draw during or after the passage of trains: *And provided further*, That if any bridge built under the provisions of this act shall be constructed with unbroken, continuous spans, it shall have one or more channel spans, each having not less than three hundred and fifty feet clear channel way and not less than fifty-five feet clear head room above high-water mark; and the clear head room under other than channel spans may be less than fifty-five feet, but no part of the superstructure of such spans shall in any case give a less head-room than ten feet above high-water mark: *And provided further*, That the interests of navigation be not injured by such reduction in height, and the piers of said bridge shall be parallel with the current of said river, and the main span shall be over the main channel of said river and give a clear width of water way of not less than three hundred and fifty feet.

Provisos.
Drawbridge.
Spans.
Low bridge.
Piers.
Opening draw.
Channel spans.

SEC. 3. That the company constructing a bridge under the provisions of this act be, and it is hereby, authorized to lay on said bridge a railway track or tracks for the more perfect connection of any railroad or railroads that are or shall be constructed to said river on either or both sides thereof, at or opposite the point of location of said bridge, under the limitations and conditions herein: *Provided*, That said bridge shall not interfere with the free navigation of said river beyond what is necessary in order to carry into effect the rights and privileges hereby granted; and in case

Railway tracks.
Proviso.
Unobstructed navigation.

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of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, the cause may be tried before the circuit court of the United States in and for any district in which any portion of said bridge or obstruction touches. Litigation.

SEC. 4. That any bridge constructed under this act and according to its limitations shall be a lawful structure, and shall be known as a post route, and the same is hereby declared to be a post route, upon which, also, no higher charges shall be made for the transmission over the same of the mails, the troops, the munitions of war of the United States, or for passengers or freight passing over said bridge, than the rate per mile paid for transportation over the railroads and public highways leading to said bridge; and equal privileges in the use of said bridge shall be granted to all telegraph companies; and the United States shall have the right of way for postal telegraph purposes across said bridge. Lawful structure and post route. Postal telegraph.

SEC. 5. That all railways desiring to use said bridge shall be entitled to equal rights and privileges in the passage of the same, and in the use of machinery and fixtures thereof, and of all the approaches thereto, under and upon such terms and conditions as shall be prescribed by the Secretary of War upon hearing the allegations and proofs of the parties, in case they shall not agree. Use by other companies. Terms.

SEC. 6. That the structure hereby authorized shall be built and located under and subject to such regulations for the security of the navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War for his examination and approval, a design of the bridge and map of location, giving for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the current at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are decided by the Secretary of War to be such as will not materially affect the interests of navigation, the bridge shall not be commenced or built; and should any change be made in the plans of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War; and the bridge shall be constructed with such aids to the passage of said bridge in the form of booms, dikes, piers, or other suitable and proper structures for confining the flow of water to a permanent channel, and for the guiding of rafts, steamboats, and other water craft safely through the draw and raft spans, as the Secretary of War shall order at any time to be constructed and maintained, at the expense of the company owning said bridge; and said structure shall be at all times so kept and managed as to offer reasonable and proper means for the passage of vessels through or under said structure; and for the safety of vessels passing at night there shall be displayed on said bridge from the hours of sunset to sunrise such lights or other signals as may be prescribed by the Light-House Board; and the said structure shall be changed or altered at the cost and expense of the owners thereof from time to time, as the Secretary of War may direct, so as to preserve the free and convenient navigation of said river; and the authority to erect and continue said bridge shall be subject to revocation and modification by law, when the public good in the judgment of Congress or the Secretary of War so requires, without any expense or charge to the United States. Secretary of War to approve plans, etc. Changes. Aids to navigation. Lights, etc.

SEC. 7. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date thereof. Commencement and completion.

SEC. 8. That the right to alter, amend, or repeal this act is hereby expressly reserved. Amendment, etc.

Approved, June 8, 1892.

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June 15, 1892.

CHAP. 118.—An act granting the use of certain lands to the city of New Bedford, Massachusetts, for a public park.

New Bedford, Mass.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there is hereby granted to the city of New Bedford, in the State of Massachusetts, the right to occupy improve, and control for the purposes of a public park for the use and benefit of the citizens of the United States, and for no other purpose whatever a portion of the tract of land owned by the United States, which is situated in the extreme southerly part of said city of New Bedford, containing sixty acres, more or less, and known as Clark's Point, and partly occupied by a fort; said tract being bounded northerly by lands owned by various private parties, and on the east, south and west by a road between it and the ocean, known as French avenue, upon the following conditions and provisions namely:

Land donated for public park.

Secretary of War to approve plans, etc.

First. That no use of said land shall be begun by the said city until after general plans of said improvement shall have been submitted to the Secretary of War and shall have been approved by him and the portion of said tract of land owned by the United States to be used for such stated purposes shall have been specially designated by him, and that no ditches shall be filled, nor embankments removed, nor structures built, repaired, altered, or removed, nor improvements of any sort begun until the extent and plans of such proposed work shall have been described in detail to the Secretary of War and shall have received his approval.

Police powers.

Second. That said city of New Bedford shall have and exercise power to make and enforce police regulations concerning said tract, and shall properly protect all said property from injury.

Fee reserved.

Third. That the United States reserves to itself the fee in said tract and the right to resume immediate and entire possession whenever either of the above provisions shall have been violated, and also to resume possession and occupy any portion thereof whenever, in the judgment of the President, the exigency arises that should require the use and appropriation of the same for public defense or otherwise, or for such other disposition as Congress may determine, without any claim for compensation to said town for improvement thereon or damage on account thereof.

Approved, June 15, 1892.

June 15, 1892.

CHAP. 119.—An act to authorize the Glen Echo Railroad Company to cross the Washington Aqueduct.

Glen Echo Railroad Company.

May cross Washington Aqueduct.

Proviso.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Glen Echo Railroad Company, a corporation duly incorporated under the laws of the State of Maryland, is hereby authorized to extend and operate its line of railway across the Washington Aqueduct and the land pertaining thereto in Montgomery County in said State: *Provided*, That the said crossing over the paved portion of the said conduit road shall be made at right angles with the said road and shall be made only at such place, in such manner, and on such conditions as shall be approved by the Secretary of War and accepted by said company, and no work shall be done on said railroad on any of said land until after such approval and acceptance in writing. At no point on the line of said Glen Echo Railroad, except at the crossing aforesaid, or of any extension of said railroad under whatever name, shall the inner rail be less than fifty feet from the middle of the paved portion of the conduit road. The operations of said company on said crossing shall always be subject to the control of the Secretary of War and to such requirements not provided for in this act as the Secretary of War may from time to time consider necessary for the safety of the aqueduct and of the public, and subject also to the right of the Secretary of War or other lawful public authority to interrupt the construction or use of said crossing

Approval by Secretary of War.

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whenever and for whatever reason it may be considered necessary for the public interests; and the agents and servants of said company, when on the public land of the United States, shall be subject to such regulations as the Secretary of War may prescribe. The said crossing shall be raised by and at the expense of said company to conform to any change of grade on the conduit road, and said company shall pave with stone and to the satisfaction of the engineer officer in charge of the Washington Aqueduct the spaces between the rails and sets of rails and two feet outside thereof and shall keep the same in good repair. Efficient signals by gong or bell shall be made by every car before and during the crossing of the Conduit road, and before crossing every car shall be brought to a complete stop, and no steam cars, locomotives, or passenger or other cars for steam railways shall ever be run over said crossing.

Grade changes.

Signals.

Expenses.

The said company shall, before commencing work on said crossing, deposit with the Treasurer of the United States, to the credit of the Washington Aqueduct, such sum as the Secretary of War may consider necessary to defray all the expenses that may be incurred by the United States in connection with the inspection of the company's work on said crossing and in making good any damages done by said company or its works or its contracting agents to the conduit or the conduit road, or to any work or land or other property of the United States, and in completing, as the Secretary of War may deem necessary, any of the company's work that the said company may neglect or refuse to complete and that the Secretary of War may consider necessary for the safety of the Washington Aqueduct and the works pertaining thereto, including its telephone line, or for the proper drainage of the Conduit Road and the land pertaining thereto, or for the proper use and orderly appearance of said road and land; and the said company shall also deposit, as aforesaid, such further sums for said purposes and at such times as the Secretary of War shall require: *Provided*, That the said moneys shall be disbursed like other moneys appropriated for the Washington Aqueduct, and that whatever shall remain of said deposits at the end of one year after the completion of said railroad shall be returned to said company, with an account of their disbursement in detail: *And provided also*, That disbursements of said deposits shall, except in case of emergency, be made only on the order of the Secretary of War. The exercise of the rights by this act granted are to terminate at the pleasure of the Secretary of War in case of persistent neglect by said company or by its successors to make the deposits or to comply with any of the conditions, requirements, and regulations aforesaid; and no claim for damages shall ever be made by said company or its successors in consequence of the exercise of any of the rights of the United States under this act.

Disbursement of moneys.

Termination of rights.

Approved, June 15, 1892.

June 21, 1892.

CHAP. 128.—An act granting the right and authority to the Mexican Gulf, Pacific and Puget Sound Railroad Company, a company organized under the laws of the States of Florida and Alabama, to build one bridge over each of the following-named rivers in the State of Alabama, namely: The Alabama River, the Warrior River, the Sipsey River, and the Tennessee River; the said bridges to be used by the Mexican Gulf, Pacific and Puget Sound Railroad Company in carrying freight and passengers by rail and otherwise.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Mexican Gulf, Pacific and Puget Sound Railroad Company, a railroad corporation organized under the laws of the States of Florida and Alabama, is hereby authorized and empowered to construct, maintain, and operate one bridge over and across each of the following-named rivers, all in the State of Alabama: The Alabama River at a point in Monroe and Clarke Counties, or in Wilcox County, Alabama; the Warrior River at a point in Hale and Greene Counties, Alabama, or at a point in Marengo and Greene Counties, Alabama; the Tennessee River at a point in the counties of Col-

Mexican Gulf, Pacific and Puget Sound Railway may bridge Alabama, Warrior, Tennessee, and Sipsey rivers, Ala.

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Railroad bridges.

Provisos.

bert and Lauderdale, Alabama; the Sipsey River at a point in Pickens or Tuscaloosa Counties, Alabama; and to lay railroad tracks on the said bridges and to run trains on the same: *Provided*, That the said bridges shall be built and located under and subject to such regulations for the security of navigation as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, designs and drawings of the bridges and complete hydrographic and topographic maps of the rivers and their banks from one mile above to one-half mile below the proposed crossings; and no bridge shall be commenced or built under the provisions of this act until the plan and location thereof have been submitted to and approved by the Secretary of War: *Provided further*, That said bridges shall be all times so managed and kept as to offer reasonable and proper means for the passage of vessels through or under them; and for the safety of vessels passing at night there shall be displayed on said bridges, from sunset to sunrise, such lights or other signals as the Light-House Board may prescribe; and all changes in said bridges required by the Secretary of War at any time, or their entire removal, shall be at the expense of the corporations or persons owning or operating said bridges.

Secretary of War to approve plans, etc.

Unobstructed navigation.

Lights, etc.

Changes.

Lawful structures and post routes.

SEC. 2. That the bridges constructed under this act and according to its limitations shall be lawful structures and shall be known as post routes, and the same are hereby declared to be post routes, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, freight, and the munitions of war of the United States than the rate per mile paid for their transportation over the railroads and public highways leading to said bridges; and equal privileges in the use of said bridges shall be granted to all telegraph companies, and the United States shall have the right of way for postal-telegraph purposes across said bridges.

Postal telegraph.

Use by other companies.

SEC. 3. That all railway companies desiring to use said bridges shall have, and be entitled to, equal rights and privileges in the passage of the same and in the use of the machinery and fixtures thereof and of all the approaches thereto, under and upon such terms and conditions as shall be prescribed by the Secretary of War upon hearing the allegations and proofs of the parties in case they shall not agree.

Terms.

Amendment, etc.

SEC. 4. That the right to alter, amend, or repeal this act is hereby expressly reserved.

Commencement and completion.

SEC. 5. That if actual construction of the bridges herein authorized shall not be commenced within two years from the passage of this act and be completed in four years from the same date, the rights and privileges hereby granted shall cease and be determined.

Approved, June 21, 1892.

June 22, 1892.

CHAP. 124.—An act to authorize the construction of a bridge across the Missouri River at the city of Yankton, South Dakota.

Yankton Bridge Company may bridge Missouri River at Yankton, S. Dak.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Yankton Bridge Company, a corporation organized for that purpose under the general corporation laws of the State of South Dakota, or its assigns, to construct, under and subject to the conditions and limitations hereafter provided, a combined railroad, wagon, and foot-passenger bridge across the Missouri River, at the city of Yankton, South Dakota, and lay on and over said bridge railway tracks for the more perfect connection of any and all railways that now are, or which may hereafter be, constructed to the Missouri River at the city of Yankton, or to the river on the opposite side of the same, near the city of Yankton, and build, erect, and lay on and over said bridge ways for wagons, vehicles of all kinds, and for the transit of animals, and to provide ways for foot

Railway, wagon, and foot bridge.

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passengers, and to maintain and operate said bridge for the purposes aforesaid; and that when said bridge is constructed all trains of railroads terminating at said river, and on the opposite side thereof, at the city of Yankton, South Dakota, shall be allowed to cross said bridge for reasonable compensation to be made to the owners of the same; and if the amount of said compensation can not be agreed upon by the parties the same shall be fixed by the Secretary of War. The owners of said bridge may also charge and receive reasonable compensation or tolls for the transit over said bridge of all wagons, carriages, vehicles, animals, and foot passengers: *Provided*, That the Secretary of War may at any time prescribe such rules, regulations, and rates of toll for transit and transportation over said bridge as may be deemed proper and reasonable. Use by railroads. Terms. Tolls. *Proviso.* Rules, etc.

SEC. 2. That any bridge built under the provisions of this act may, at the option of the corporation building the same, be built as a drawbridge, or with unbroken or continuous spans: *Provided*, That if the same shall be made of unbroken continuous spans, it shall not be in any case of less elevation than fifty feet above extreme high-water mark, as understood at the point of location, to the lowest part of the superstructure, with straight girders; nor shall the spans of said bridge be less than three hundred feet in the clear at low-water mark; and the piers of said bridge shall be parallel with the current of the river at high water, and the main spans shall be over the main channels of the river: *And provided also*, That if a bridge shall be built under this act as a drawbridge the same shall be constructed as a pivot drawbridge, with one or more draws, as the Secretary of War may prescribe, and with spans of not less than two hundred feet in length in the clear on each side of the central or pivot piers of the draws, and the next adjoining spans over the river to the draws shall not be less than two hundred and fifty feet in the clear, measured at low water; and said spans shall not be less than ten feet above extreme high-water mark, measuring to the lowest part of the superstructure of the bridge; and the piers of said bridge shall be parallel with the current of the river at high water: *And provided also*, That said draw shall be opened promptly, upon reasonable signal, without unnecessary delay; and said company or corporation shall maintain, at its own expense, from sunset till sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe, and such sheer booms or other structures as may be necessary to safely guide vessels, rafts, or other water craft safely through said channel spans or draw openings, and as shall be designated and required by the Secretary of War: *And provided further*, That the corporation building said bridge may, subject to the approval of the Secretary of War, enter upon the banks of said river, either above or below the point of location of said bridge, and confine the flow of the water to a permanent channel, and to do whatever may be necessary to accomplish said object, but shall not impede or obstruct the navigation of said river, and shall be liable in damages for all injuries to private property, and all plans for such works or erections upon the banks of the river shall first be submitted to the Secretary of War for his approval: *And provided further*, That any bridge built under the provisions of this act shall be at right angles to the current of the river at high water. Construction. *Provisos.* Spans. Draw. Opening draw. Lights, etc. Channel may be made.

SEC. 3. That no bridge shall be erected or maintained under the authority of this act which shall at any time substantially or materially obstruct the free navigation of said river; and no bridge shall be commenced or built under this act until the location thereof and the plans and specifications for its construction shall have been submitted to and approved by the Secretary of War; and any change in the plan of such construction or any alteration in the bridge after its construction shall be subject to the like approval; and whenever said bridge shall, in the opinion of the Secretary of War, substantially obstruct the free navigation of said river, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction; and all such alterations shall be made and all such obstructions be removed Unobstructed navigation. Secretary of War to approve plans, etc. Alterations.

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at the expense of the owner or owners of said bridge, or the persons operating or controlling the same; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of the Missouri River, at or near the crossing of said bridge, caused or alleged to be caused thereby, the cause shall be commenced and tried in the circuit courts of the United States of either judicial district of South Dakota or Nebraska in which the said bridge or any portion of such obstruction touches.

Litigation.

Lawful structure and post route.

SEC. 4. That any bridge built under this act and according to its limitations shall be a lawful structure, and shall be recognized and known as a post route, upon which also no higher charge shall be made for the transportation over the same of the mails, the troops, and munitions of war of the United States than the rate per mile paid for their transportation over the railroad or public highways leading to such bridge. The United States shall also have the right to construct, without charge therefor, telegraph or telephone lines across said bridge.

Amendment, etc.

SEC. 5. That Congress may at any time alter, amend, or repeal this act.

Commencement and completion.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within two years, and completed within four years from the date hereof.

Approved, June 22, 1892.

June 22, 1892.

CHAP. 125.—An act authorizing the Continental Bridge Company to construct a bridge across the Rio Grande River at or near Brownsville, Texas.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Continental Bridge Company, by and with the consent of the Government of Mexico, is hereby authorized and empowered to erect, construct, maintain, and operate a bridge over the Rio Grande del Norte from or near Brownsville, in the State of Texas, to or near the city of Matamoras, in Mexico. Said bridge shall be constructed to provide for the passage of railway trains and street railways and for the passage of wagons and vehicles of all kinds, for the transit of animals, and for foot passengers, for such reasonable rates of toll as may be approved from time to time by the Secretary of War.

Continental Bridge Company may bridge Rio Grande del Norte at Brownsville, Tex.

Railway, etc., bridge.

Toll.

Lawful structure and post route.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post route, and it shall enjoy the rights and privileges of other post roads of the United States.

Draw.

Provisos.

Opening draw.

Lights, etc.

Changes.

Litigation.

SEC. 3. That said bridge shall be constructed with a draw of sufficient capacity to afford free passage to such vessels and boats as navigate said river: *Provided*, That said bridge shall be opened promptly upon reasonable signal for the passage of boats and other water craft, except when trains are passing over the draw; but in no case shall unnecessary delay occur in opening the draw after the passage of trains, or at any other time; and the said Continental Bridge Company shall maintain, at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the United States Light-House Board shall prescribe. And no bridge shall be erected and maintained under the authority of this act which shall at any time substantially or materially obstruct the free navigation of said river; and if any bridge erected under such authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of such bridge to be made as will effectually obviate such obstruction; and all such alterations shall be made and all such obstructions be removed at the expense of the owner of said bridge. And in case of any obstruction or alleged obstruction to the navigation of said river, caused or alleged to be caused by said bridge, any action arising thereon may be brought in the circuit court of the United States in which any portion of said obstruction or bridge may be located: *Provided further*, That nothing

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in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same. General laws not modified.

SEC. 4. That any bridge authorized to be constructed under this act shall be located and built under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said corporation shall, at least three months previous to the commencement of the construction of said bridge, submit to the Secretary of War, for his examination and approval, a design and drawing of the bridge, and a map of the location, giving the high and low water lines upon the banks of the river, the direction and strength of the currents at all stages of the water, with the soundings accurately showing the bed of the stream, and the location of any other bridge or bridges, such map to be sufficiently in detail to enable the Secretary of War to judge of the proper location of said bridge, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until such plan and location of the bridge are approved by the Secretary of War the bridge shall not be commenced or built; and should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War. Secretary of War to approve plans, etc.

SEC. 5. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same and over the approaches thereto, upon the payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid and upon the rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties. Use by other companies. Terms.

SEC. 6. That the right to alter, amend, or repeal this act is hereby expressly reserved; and the right to require any changes in said structure, or its entire removal, at the expense of the owners thereof, whenever Congress shall decide that the public interest requires it, is also expressly reserved. Amendment, etc.

SEC. 7. That it shall be the duty of the Secretary of War, on satisfactory proof that a necessity exists therefor, to require the company or persons owning said bridge to cause such aids to the passage of said bridge to be constructed, placed, and maintained, at their own cost and expense, in the form of booms, dikes, piers, or suitable and proper structures for the guiding of rafts, steamboats, and other water craft safely through the passageway as shall be specified in his order in that behalf; and on failure of the company or persons aforesaid to make and establish such additional structures within a reasonable time the said Secretary shall proceed to cause the same to be built or made at the expense of the United States, and shall refer the matter without delay to the Attorney-General of the United States, whose duty it shall be to institute, in the name of the United States, proceedings in any circuit court of the United States in which such bridge or any part thereof is located for the recovery of the cost of such additional structure; and all moneys accruing from such proceedings shall be covered into the Treasury of the United States. Aids to navigation.

SEC. 8. That the consent of the authorities of the Republic of Mexico for the construction of said bridge shall first have been obtained before said bridge shall be built or commenced. Consent of Mexico.

SEC. 9. That this act shall be in force from and after its passage.

SEC. 10. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within two years and completed within four years from the passage of this act. Commencement and completion.

SEC. 11. That Congress is hereby authorized to alter, amend, or repeal this act. Amendment, etc.

Approved, June 22, 1892.

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June 22, 1892.

CHAP. 126.—An act authorizing the Quincy Pontoon Bridge Company to construct and maintain a pontoon bridge across the Mississippi River at the city of Quincy, in the State of Illinois.

Quincy Pontoon Bridge Company may bridge Mississippi River at Quincy, Ill.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Quincy Pontoon Bridge Company, its successors and assigns, to build, construct, and maintain a pontoon wagon and foot bridge across the Mississippi River at a point suitable to the interests of navigation, in or near the corporate limits of the city of Quincy, in Adams County, in the State of Illinois, and extending across said river to the Missouri shore opposite to said city.

Draw.

SEC. 2. That said bridge shall be constructed with a suitable pontoon draw giving not less than four hundred feet clear channel way for each navigable channel of the river, and such other openings for the passage of rafts and logs as in the opinion of the Secretary of War may be necessary: *Provided*, That said draws shall be opened promptly upon reasonable signal to allow the passage of boats.

Proviso. Opening draw.

Secretary of War to approve plans, etc.

SEC. 3. That said bridge shall be built and located under and subject to such regulations for the security of the navigation of said river as the Secretary of War shall prescribe; and to secure that object the said parties shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge, and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore lines at low and high water, the direction and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be commenced or built, and should any changes be made in the plan of said bridge during the progress of construction or after completion, such changes shall be subject to the approval of the Secretary of War; and the said bridges shall be constructed with such aids to the passage of said bridge, in the form of booms, dikes, piers, or other suitable and proper structures for confining the flow of water to a permanent and easily navigated channel, for a distance of not less than one mile above the bridge location, and for the guiding of rafts, steamboats, and other water craft safely through the draw and raft spans, as the Secretary of War shall prescribe and order to be constructed and maintained at the expense of the company owning said bridge; and the said structure shall be at all times so kept and managed as to offer reasonable and proper means for the passage of vessels through said structure.

Changes.

Aids to navigation.

Lights, etc.

SEC. 4. That the said parties shall maintain at their own expense, from sunset till sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe.

Amendment, etc.

SEC. 5. That the right to alter, amend, or repeal this act, or any part thereof, at any time, by the Congress of the United States, is hereby expressly reserved; and any change in the construction or any alteration of said bridge that may be directed at any time by Congress or the Secretary of War, shall be at the expense of the owners of said bridge or the parties operating and controlling the same.

Commencement and completion.

SEC. 6. That if actual construction of the bridge herein authorized shall not be commenced within one year and completed within three years from the date of the approval of this act the rights and privileges hereby granted shall cease and be determined.

Approved, June 22, 1892.

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CHAP. 138.—An act for the relief of the Kentucky and Indiana Bridge Company.

June 30, 1892.

Kentucky and Indiana Bridge Company.

May acquire part of land of Louisville and Portland Canal.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Kentucky and Indiana Bridge Company, a corporation created by and existing under the laws of the Commonwealth of Kentucky, be, and it hereby is, authorized to occupy and acquire title to so much of the land of the Louisville and Portland Canal, the property of the United States, as is now occupied by the south abutment of the said Kentucky and Indiana bridge and the contiguous trestles in the approach thereto, on the payment to the United States by the said bridge company of the fair value of such specified tract, to be determined by agreement between the said Kentucky and Indiana Bridge Company and the Secretary of War.

Approved, June 30, 1892.

CHAP. 143.—An act to amend the charter of the Eckington and Soldiers' Home Railroad Company.

July 5, 1892.

Eckington and Soldiers' Home Railroad Company, D. C. Extension of tracks authorized.

Vol. 25, p. 190; vol. 26, p. 77.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the charter of the Eckington and Soldiers' Home Railway Company be, and the same is hereby, amended so as to authorize said company to lay its tracks and to run its cars thereon through and along the following named streets and avenues: Beginning at the intersection of Fifth and G streets northwest, east along G street to New Jersey avenue and First street; thence south along First street northwest to C street northwest; thence east along C street to New Jersey avenue; thence south along New Jersey avenue to a point in the center of said avenue at a distance of not less than one hundred and fifty feet from the north curb line of B street north. Returning north along New Jersey avenue to D street; thence west on D street to First street northwest; thence north on First street to G street, and along G street to Fifth street northwest; also, beginning at the intersection of G street and New Jersey avenue; thence across New Jersey avenue to and along G street to North Capitol street; thence north along North Capitol street to New York avenue, connecting with its main line and North Capitol street branch: also beginning at the intersection of Fifth and G streets northwest; thence south on Fifth street to Louisiana avenue; thence southwesterly on Louisiana avenue to a point to be located by the Commissioners of the District of Columbia, east of Seventh street northwest, and returning by the same route to the said point of beginning; also beginning at the intersection of New Jersey avenue and C street northwest; thence east on C street to Stanton square; thence around Stanton square, on the south side thereof, to C street northeast and along C street to Fifteenth street northeast; thence north on Fifteenth street to D street northeast; thence west on D street to Fourth street; thence south on Fourth street to and along C street to New Jersey avenue and the point of beginning: *Provided,* That until C and D streets shall be paved and provided with sewers to Fifteenth street the company shall not be required to construct its road beyond Twelfth street; also beginning at the present terminus of the Eckington and Soldiers' Home road on Fourth street extended, thence along and wholly outside of the present Bunker Hill road, on land to be acquired by said company by gift or purchase and made a part of said road, to a point to be located by the Commissioners of the District of Columbia, west of Brooks station: * * * *Provided,* That the construction of said railroad on any street where there are or may be any mains, fixtures, or apparatus pertaining to the Washington Aqueduct shall be subject to such conditions as may be approved by the Secretary of War, which conditions must be obtained and be accepted in writing by said company

Provisos.

Bunker Hill road.

Approval of Secretary of War for work on streets having water mains, etc.

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before commencing any work on such street and no steam cars, locomotives, or passenger or other cars for steam railroads shall ever be run on the tracks of said company over any such main, fixture, or apparatus. The said railroad shall be subject to the requirements of section fifteen of the act of Congress approved February twenty-eighth, eighteen hundred and ninety-one, entitled "An act to incorporate the Washington and Arlington Railway Company of the District of Columbia." The said company shall, before commencing work on said railroad on such street, deposit with the Treasurer of the United States to the credit of the Washington Aqueduct such sum as the Secretary of War may consider necessary to defray all the expenses that may be incurred by the United States in connection with the inspection of the work of construction of said railroad on such street, and in making good any damages done by said company, or its works, or by any of its contracting agents, to any of said mains, fixtures, or apparatus, and in completing, as the Secretary of War may deem necessary, any of the work that the said company may neglect or refuse to complete and that the Secretary of War may consider necessary for the safety of said mains, fixtures, or apparatus, and the said company shall also deposit as aforesaid such further sums for said purposes at such times as the Secretary of War may consider necessary: *Provided*, That the said sums shall be disbursed like other moneys appropriated for the Washington Aqueduct, and that whatever shall remain of said deposits at the end of one year after the completion of said railroad in such street shall be returned to said company on the order of the Secretary of War, with an account of their disbursement in detail: *And provided also*, That disbursements of said deposits shall, except in case of emergency, be made only on the order of the Secretary of War. The exercise of the rights by this act granted are to terminate at the pleasure of the Secretary of War in case of persistent neglect by said company, or by its successors, to make the deposits, or to comply with any of the conditions, requirements, and regulations aforesaid. * * *

Protection of water pipes, etc.
Vol. 26., p. 793.
Deposit to defray expenses.
Disbursements.
Return of balance.
Rights to terminate on neglect, etc.

Amendment, etc.

SEC. 4. That Congress reserves the right to alter, amend, or repeal this act.

Approved, July 5, 1892.

July 5, 1892.

CHAP. 144.—An act to incorporate the District of Columbia Suburban Railway Company.

District of Columbia Suburban Railway Company incorporated.
Incorporators.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Richard K. Cralle, Charles E. Creecy, John T. Mitchell, M. F. Morris, J. W. Denver, L. G. Hine, Gilbert Moyers, S. E. Mudd, Robert A. Howard, W. I. Hill, John W. Childress, J. F. Kenney, D. W. Glassie, Harry Barton, Philemon W. Chew, T. C. Daniel, G. P. Davis, Jere Johnson and L. C. Loomis, and their associates successors, and assigns, are hereby created a body corporate by the name, style, and title of "The District of Columbia Suburban Railway Company," and by that name shall have perpetual succession, and shall be able to sue and be sued, plead and be impleaded, defend and be defended, in all courts of law and equity within the United States, and may make and have a common seal. And said corporation is hereby authorized to construct and lay down a single or double track railway, as may be approved by the Commissioners of the District of Columbia, with the necessary switches, turn-outs, and other mechanical devices, in the District of Columbia, through and along the following routes: Beginning at the dividing line between the District of Columbia and the State of Maryland, on the Bladensburg road, and running thence along the said road so that the outer rail of said railway shall not be more than five feet from the eastern boundary of said Bladensburg road, to H. street east; thence west on H. street east to Seventh street east, over the tracks of the Columbia Railroad.

May lay tracks, etc.
Routes.
Bladensburg road.

* * * * * * *

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Also from the intersection of Florida avenue with Twelfth street northeast, to H street northeast, on Twelfth street: thence west on H street over the tracks of the Columbia road to Seventh street east; thence south on Seventh street by single track to G street east; thence west on G street by single track to First street west; thence by a route to be laid down by the Commissioners of the District of Columbia across New Jersey avenue to the tracks of the Capitol, North O and South Washington Railroad; thence on the tracks of the last-named road on G street to Fourth street, continuing west on G street west to Fifth street; thence south on Fifth street west, in part over the tracks of the Metropolitan Railroad, to Louisiana avenue; thence south-westerly by double track on Louisiana avenue to a point to be located by the Commissioners of the District of Columbia east of Seventh street west. Returning north-easterly on Louisiana avenue to Fifth street west; thence over the tracks of the Metropolitan Railroad along Judiciary Square to Fourth street west; thence north on Fourth street west by single track to E street west; thence east on E street by single track to Eighth street east; thence north by single track on Eighth street to H street; thence east over the tracks of the Columbia Railroad to Twelfth street; thence north on Twelfth street to Florida avenue: In Washington City.

* * * * * * *

SEC. 2. That said company may run public carriages propelled by cable, electric, or other mechanical power: Motive power

* * * * * * *

SEC. 8. That it shall be lawful for said corporation, its successors or assigns, to make all needful and convenient trenches and excavations in any of said streets, or places where said corporation may have the right to construct and operate its road, and place in such trenches and excavations all needful and convenient devices and machinery for operating said railroad in the manner and by the means aforesaid, subject to the approval of the said Commissioners. But whenever such trenches or excavations shall interfere with any sewer, gas, or water pipes, or any subways or conduits, or any public work of the kind which has been ordered by the Commissioners, then the expense necessary to change such underground construction shall be borne by the said railway company: Construction.

* * * *Provided also*, That the construction of said railroad on any street where there are or may be any mains, fixtures, or apparatus pertaining to the Washington Aqueduct shall be subject to such conditions as may be approved by the Secretary of War, which conditions must be obtained and be accepted in writing by said company before commencing any work on such street; and no steam cars, locomotives, or passenger or other cars for steam railroads shall ever be run on the tracks of said company over any such main, fixture or apparatus. Approval of Secretary of War for work on streets having water mains, etc.

The said railroad shall be subject to the requirements of section fifteen of the act of Congress approved February twenty-eighth, eighteen hundred and ninety-one, entitled "An act to incorporate the Washington and Arlington Railway Company of the District of Columbia." The said company shall, before commencing work on said railroad on such street, deposit with the Treasurer of the United States to the credit of the Washington Aqueduct such sum as the Secretary of War may consider necessary to defray all the expenses that may incurred by the United States in connection with the inspection of the work of construction of said railroad on such street, and in making good any damages done by said company, or its works, or by any of its contracting agents, to any of said mains, fixtures, or apparatus, and in completing, as the Secretary of War may deem necessary, any of the work that the said company may neglect or refuse to complete and that the Secretary of War may consider necessary for the safety of said mains, fixtures, or apparatus, and the said company shall also deposit as aforesaid such further sums for said purposes at such times as the Secretary of War may consider necessary: *Provided*, That the said sum shall be disbursed like other moneys appropriated for Protection of water pipes, etc. Vol. 26, p. 793. Deposit to defray expenses. Disbursement.

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the Washington Aqueduct, and that whatever shall remain of said deposits at the end of one year after the completion of said railroad in such street shall be returned to said company on the order of the Secretary of War, with an account of its disbursement in detail: *And provided also*, That disbursements of said deposits shall, except in cases of emergency, be made only on the order of the Secretary of War. The exercise of the rights by this act granted are to terminate at the pleasure of the Secretary of War in case of persistent neglect by said company, or by its successors, to make the deposits, or to comply with any of the conditions, requirements, and regulations aforesaid.

Return of balance.

Rights to terminate on neglect, etc.

*   *   *   *   *   *   *

Commencement and completion.

SEC. 11. That the line of said railway company shall be commenced within six months and completed within two years from the passage of this act, otherwise this act shall be of no effect.

*   *   *   *   *   *   *

Amendment, etc.

SEC. 23. This act may at any time be altered, amended, or repealed by the Congress of the United States.

*   *   *   *   *   *   *

Approved, July 5, 1892.

July 13, 1892.

CHAP. 157.—An act to amend an act entitled "An act to authorize the Oregon and Washington Bridge Company to construct and maintain a bridge across the Columbia River, between the State of Oregon and the State of Washington, and to establish it as a post road."

Bridge across Columbia River by Oregon and Washington Bridge Company.

Time for construction extended.

Vol. 26, p. 28.

Ante, p. 19.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That, "An act to authorize the Oregon and Washington Bridge Company to construct and maintain a bridge across the Columbia River, between the State of Oregon and the State of Washington, and to establish it as a post road," approved March twenty-fourth, eighteen hundred and ninety, be and the same is hereby, extended, revived, and declared to be in full force and effect from and after March twenty-fourth, eighteen hundred and ninety-two. Section twelve of said act, which provides that said act shall be null and void if actual construction of the bridge therein authorized be not commenced within two years and completed within four years from the date of the approval thereof, shall be, and the same is hereby, so amended that the time within which said bridge is required to be commenced shall be within two years from March twenty-fourth, eighteen hundred and ninety-two, and the time within which it is required that said bridge be completed shall be within four years from the twenty-fourth day of March, eighteen hundred and ninety-two.

Approved, July 13, 1892.

July 13, 1892.

CHAP. 158.—An act making appropriations for the construction, repair and preservation of certain public works on rivers and harbors, and for other purposes.

Appropriations for rivers and harbors.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums of money be, and are hereby, appropriated, to be paid out of any money in the Treasury not otherwise appropriated, to be immediately available, and to be expended under the direction of the Secretary of War and the supervision of the Chief of Engineers, for the construction, completion, repair, and preservation of the public works hereinafter named:

Harbors.

Camden, Me.

Improving harbor at Camden, Maine: Continuing improvement, twelve thousand dollars.

Rockland, Me.

Improving harbor at Rockland, Maine: Continuing improvement, thirty thousand dollars.

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Improving Mooseabec Bar, Maine: Continuing improvement, fifteen thousand dollars. Mooseabec Bar, Me.

Improving harbor at York, Maine: Completing improvement, nine thousand dollars. York, Me.

Improving harbor at Portland, Maine: Completing improvement, thirty thousand dollars. Portland, Me.

Improvement of channel in Back Cove, Portland Harbor, Maine: Continuing improvement, twenty thousand dollars. Back Cove, Portland, Me.

For construction of breakwater from Mount Desert to Porcupine Island, Maine: Continuing improvement, fifty thousand dollars. Mount Desert to Porcupine Island, Me., breakwater.

Improving harbor at Belfast, Maine: Continuing improvement, ten thousand dollars. Belfast, Me.

Improving harbor of refuge at Little Harbor, New Hampshire, Continuing improvement, thirty thousand dollars. Little Harbor, N. H.

Improving harbor at Boston, Massachusetts: Continuing improvement, by deepening and widening the main channel to a depth of twenty-seven feet and a width of one thousand feet, three hundred thousand dollars, of which ten thousand dollars may, in the discretion of the Secretary of War, be used in the further prosecution of the work in Nantasket Beach Channel, and twenty-five thousand dollars in extending main ship channel from its termination at the southeast corner of Grand Junction wharf eastwardly towards Jeffrey's Point. Boston, Mass.

Improving harbor at Lynn, Massachusetts: Continuing improvement, ten thousand dollars: *Provided*, That the whole or any portion of this appropriation may be expended on the Western channel in the discretion of the Secretary of War. Lynn, Mass *Proviso.*

Improving harbor of refuge at Nantucket, Massachusetts: Continuing improvement, twenty-five thousand dollars. Nantucket, Mass.

Improving harbor at Newburyport, Massachusetts: Continuing improvement, twenty thousand dollars. Newburyport, Mass.

Improving harbor at Plymouth, Massachusetts: Completing improvement, nine thousand five hundred dollars. Plymouth, Mass.

For maintenance of works in harbor at Provincetown, Massachusetts, one thousand five hundred dollars. Provincetown, Mass.

Improving harbor at Wareham, Massachusetts: Completing improvement, seven thousand two hundred and thirty-six dollars. Wareham, Mass.

Improving harbor at Hingham, Massachusetts: Completing improvement, three thousand dollars. Hingham, Mass.

Improving harbor at Hyannis, Massachusetts: Continuing improvement, six thousand dollars. Hyannis, Mass.

Improving harbor at Vineyard Haven, Massachusetts: Continuing improvement, seven thousand five hundred dollars. Vineyard Haven, Mass.

Improving national harbor of refuge at Sandy Bay Cape Ann, Massachusetts: Continuing improvement, one hundred and fifty thousand dollars. Sandy Bay, Cape Ann, Mass.

Improving harbor at Gloucester, Massachusetts: Continuing improvement, forty thousand dollars. Gloucester, Mass.

Improving harbor at Manchester, Massachusetts: Completing improvement, six thousand eight hundred dollars. Manchester, Mass.

Improving harbor at New Bedford, Massachusetts: Continuing improvement, seven thousand five hundred dollars. New Bedford, Mass.

Improving inner harbor at Marthas Vinyard, Massachusetts: Completing improvment, two thousand five hundred dollars. Marthas Vineyard, Mass.

Improving harbor at Salem, Massachusetts: Completing improvement, fourteen thousand dollars. Salem, Mass.

Improving harbor at Westport, Massachusetts: Completing improvement, one thousand dollars. Westport, Mass.

Improving Canapitsit Channel, Massachusetts, between the islands of Cuttyhunk and Neshawana, completing improvement, four thousand eight hundred dollars. Canapitsit Channel, Mass.

Improving harbor at Scituate, Massachusetts: Continuing improvement, ten thousand dollars. Scituate, Mass.

Improving harbor at Winthrop, Massachusetts: Continuing improvement, three thousand dollars. Winthrop, Mass.

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Kingston, Mass. North Plymouth, Mass. Improving harbor at Kingston, Massachusetts, and the approaches to the public wharves of said port and of North Plymouth, ten thousand dollars.

Block Island, R. I. Improving harbor at Block Island, Rhode Island: Completing improvement, twenty-four thousand dollars.

Newport, R. I. Improving harbor at Newport, Rhode Island, including the removal of the spit at the south end of Goat Island, Continuing improvement, twenty-five thousand dollars.

Point Judith, R. I. Harbor of refuge. *Proviso.* Contracts. Limit. Constructing harbor of refuge at Point Judith, Rhode Island: Continuing construction, seventy-five thousand dollars: *Provided*, That contracts may be entered into by the Secretary of War for such materials and work as may be necessary to complete the present project of improvement, to be paid for as appropriations may, from time to time, be made by law, not to exceed in the aggregate one million and one hundred thousand dollars, exclusive of the amount herein and heretofore appropriated.

Point Judith Pond, R. I. Improving entrance to Point Judith Pond, west of Point Judith, Rhode Island, seven thousand five hundred dollars.

Bridgeport, Conn. Improving harbor at Bridgeport, Connecticut: Continuing improvement, between Inner Beacon and Naugatuck wharf, twenty thousand dollars.

Black Rock, Conn. Improving harbor at Black Rock, Connecticut: Continuing improvement, five thousand dollars.

New Haven, Conn., breakwaters. Constructing breakwaters at New Haven, Connecticut: Continuing construction, one hundred and twenty thousand dollars.

Stonington, Conn. Improving harbor at Stonington, Connecticut: Completing improvement, twelve thousand five hundred dollars.

Clinton, Conn. Improving harbor at Clinton, Connecticut: Continuing improvement, two thousand dollars.

Five-mile River, Conn. Improving harbor at Five-mile River, Connecticut: Continuing improvement, five thousand dollars.

Duck Island, Conn. Improving harbor of refuge at Duck Island, on Long Island Sound, Connecticut: Continuing improvement, thirty-five thousand dollars.

New Haven, Conn. Improving harbor at New Haven, Connecticut: Continuing improvement, fifteen thousand dollars.

Stamford, Conn. Improving harbor at Stamford, Connecticut: Fifteen thousand dollars, not less than one-half of which shall be expended on the East Branch.

Cos Cob and Miamus River, Conn. Improving harbor at Cos Cob and Miamus River, Connecticut, seven thousand dollars.

Buffalo, N. Y. Improving harbor at Buffalo, New York: Continuing improvement, three hundred thousand dollars.

Rouses Point, N. Y. Constructing breakwater at Rouses Point, New York: Completing improvement, fifteen thousand dollars.

Canarsie Bay, N. Y. Improving harbor at Canarsie Bay, New York: Continuing improvement, five thousand dollars.

Charlotte, N. Y. Improving harbor at Charlotte, New York: Continuing improvement, twenty-five thousand dollars.

Dunkirk, N. Y. Improving harbor at Dunkirk, New York: Continuing improvement, twenty thousand dollars.

Flushing Bay, N. Y. Improving harbor at Flushing Bay, New York: Continuing improvement, ten thousand dollars.

Glen Cove, N. Y. Improving harbor at Glen Cove, New York: Continuing improvement, ten thousand dollars.

Gowanus Bay, N. Y. Improving Gowanus Bay channels, New York: Continuing improvement, one hundred thousand dollars, for distribution by allotment between the Red Hook and Gowanus Creek channels, at the discretion of the Secretary of War.

Bay Ridge Channel, N. Y. Improving Bay Ridge channel, Gowanus Bay, New York Harbor, New York: Completing improvement, ninety-eight thousand six hundred dollars.

Great Sodus Bay, N. Y. Improving harbor at Great Sodus Bay, New York: Continuing improvement, fifteen thousand dollars.

Greenport, N. Y. Improving harbor at Greenport, New York: Completing improvement, eleven thousand dollars.

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Improving harbor at Little Sodus Bay, New York: For maintenance of existing works and deepening of channel, six thousand dollars. Little Sodus Bay, N. Y.

Improving harbor at Ogdensburg, New York: Continuing improvement, forty thousand dollars. Ogdensburg, N. Y.

Improving harbor at Oswego, New York: Continuing improvement, forty thousand dollars. Oswego, N. Y.

Improving harbor at Rondout, New York: For repairs to existing works, five thousand dollars. Rondout, N. Y.

Improving New York Harbor, New York: Continuing improvement, one hundred and seventy thousand dollars. New York, N. Y.

Improving harbor at Saugerties, New York: To maintain the dike in repair and to remove the rocky points near the shore end of the north dike, five thousand dollars. Saugerties, N. Y.

Improving harbor at Port Chester, New York: Continuing improvement, five thousand dollars. Port Chester, N. Y.

Improving Tonawanda Harbor and Niagara River, New York: Continuing improvement, seventy-five thousand dollars. Tonawanda Harbor, Niagara River, N. Y.

Improving channel between Staten Island and the New Jersey shore, New York and New Jersey: Continuing improvement, fifteen thousand dollars. Channel, Staten Island and New Jersey.

Improving Arthur Kill, between Staten Island and New Jersey shore, New York and New Jersey: Continuing improvement, five thousand dollars. Arthur Kill, N. Y. and N. J.

Improving harbor at Huntington, New York: Continuing improvement, five thousand dollars. Huntington, N. Y.

Improving Buttermilk Channel, New York Harbor, one hundred thousand dollars. Buttermilk Channel, N. Y.

Improving harbor at Port Jefferson Inlet, New York: Continuing improvement, ten thousand dollars. Port Jefferson, N. Y.

Improving harbor at Pultneyville, New York: Continuing improvement, one thousand dollars. Pultneyville, N. Y.

Improving Jamaica Bay, New York: Completing improvement in accordance with plan numbered three of Lieutenant-Colonel Gillespie, Corps of Engineers, submitted December sixteenth, eighteen hundred and ninety, nine thousand four hundred and sixty dollars. Jamaica Bay, N. Y.

Improving harbor at Raritan Bay, New Jersey: Continuing improvement, forty thousand dollars, one-half of which, in the discretion of the Secretary of War, may be used in dredging bar between South Amboy and Great Beds Light. Raritan Bay, N. J.

Improving Keyport Harbor, New Jersey: Continuing improvement, five thousand dollars. Keyport, N. J.

Improving harbor at Erie, Pennsylvania: Continuing improvement, forty thousand dollars. Erie, Pa.

The material removed in improving the harbor of Philadelphia, Pennsylvania and New Jersey, in accordance with the plan adopted by Congress in the act of September nineteenth, eighteen hundred and ninety, under appropriations heretofore made, or any part of said material, may be deposited in any place or places approved by the engineer officer in charge of the work: *Provided*, That the full amount of material to be deposited and spread on League Island, as provided for under the existing contract, shall be so deposited and spread before the completion of the work covered by the contract; and all acts or parts of acts inconsistent or in conflict with this provision are hereby repealed. Philadelphia, Pa. Deposit of material. *Proviso.* League Island

Improving Delaware Breakwater, Delaware: Continuing improvement, fifty thousand dollars. Delaware Breakwater, Del.

Improving harbor at Wilmington, Delaware: Continuing improvement, forty thousand dollars. Wilmington, Del.

Improving harbor at Cambridge, Maryland: Completing improvement, seven thousand seven hundred and thirty-seven dollars: *Provided*, That no part of said sum shall be expended above the bridge until the draw in said bridge shall have been widened sufficiently to accommodate the commerce on the river. Cambridge, Md. *Proviso.* Removal of draw.

Improving harbor at Norfolk and its approaches, Virginia: Continuing improvement, one hundred and fifty thousand dollars. Norfolk, Va.

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Onancock, Va. Improving harbor at Onancock, Virginia: Completing improvement, six thousand five hundred and eleven dollars.

Cape Charles City, Va. Improving harbor at Cape Charles City, Virginia, and its approaches; Continuing improvement, ten thousand dollars, to be expended in dredging and for such protective works as are recommended by the engineer: *Provided*, That, before any Government money shall be expended in the improvement of this harbor or any of its approaches, the owners of the basin forming the harbor and the channel or canal leading thereto, or connecting said harbor withe Cherrystone Inlet, shall execute, or cause to be executed, and file with the Secretary of War an instrument in writing, satisfactory to the said Secretary of War, giving to any and all vessels, upon any and all occasions for all time to come, the right to enter and remain in said harbor and transact business therein without charge, except legitimate, usual, and reasonable wharf charges to be determined by the Secretary of War in event of disagreement and shall further legally dedicate or cause to be dedicated to public use an approach to the wharves of said harbor from the nearest public highway of not less than forty feet in width, to be approved by the Secretary of War.

Proviso.

Use of basin.

Wharf charges.

Beaufort, N.C. Improving harbor at Beaufort, North Carolina: Continuing improvement, ten thousand dollars.

Charleston, S. C. Improving harbor at Charleston, including Sullivan Island and Mount Pleasant Shore, South Carolina: Continuing improvement, two hundred and twenty-five thousand dollars: *Provided*, That contracts may be entered into by the Secretary of War for such materials and work as may be necessary to complete the present project of improvement, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate one million nine hundred and fifty-three thousand dollars, exclusive of the amount herein and heretofore appropriated.

Proviso.

Contracts.

Limit.

Georgetown, S. C. Improving harbor at Georgetown, South Carolina: Completing improvement, twelve thousand dollars.

Winyaw Bay, S. C. Improving harbor at Winyaw Bay, South Carolina: Continuing improvement, one hundred thousand dollars.

Brunswick, Ga. Improving harbor at Brunswick, Georgia: Completing improvement, twenty-seven thousand five hundred dollars.

Cumberland Sound, Ga. Improving Cumberland Sound, Georgia: Continuing improvement, one hundred and seventy thousand dollars.

Savannah, Ga. Improving harbor at Savannah, Georgia: Continuing improvement, three hundred and eighteen thousand seven hundred and fifty dollars: *Provided*, That contracts may be entered into by the Secretary of War for such materials and work as may be necessary to complete the present project of improvement, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate two million eight hundred and thirty-one thousand two hundred and fifty dollars, exclusive of the amount herein and heretofore appropriated.

Proviso.

Contracts.

Limit.

Darien, Ga. Improving harbor at Darien, Georgia: Continuing improvement, twenty-five thousand dollars.

Apalachicola Bay and River, Fla. Improving harbor at Apalachicola Bay and River, Florida: Continuing improvement, twenty thousand dollars.

Pensacola, Fla. Improving harbor at Pensacola, Florida: Continuing improvement, to obtain twenty-four feet of water by dredging, seventy-five thousand dollars.

Tampa Bay, Fla. Improving harbor at Tampa Bay, Florida: Completing improvement, ten thousand dollars.

Key West, Fla. Improving entrance to harbor at Key West, Florida: Continuing improvement, seventy-five thousand dollars.

Saint Augustine, Fla. Improving harbor at Saint Augustine, Florida: Completing improvement, ten thousand dollars.

Mobile, Ala. Improving harbor at Mobile, Alabama: Continuing improvement, two hundred and twelve thousand five hundred dollars: *Provided*, That contracts may be entered into by the Secretary of War for such materials and work as may be necessary to complete the present project of improvement, to be paid for as appropriations may from time to time be made by law, not to exceed in the ag-

Proviso.

Contracts.

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gregate one million one hundred and eighty-one thousand three hundred dollars, exclusive of the amount herein and heretofore appropriated. Limit.

Improving mouth and passes of Calcasieu River, Louisiana: Continuing improvement, one hundred thousand dollars, of which twenty thousand dollars or so much thereof as may be necessary, may, in the discretion of the Secretary of War, be used on the inner bars. Calcasieu River, La.

Improving and maintaining ship channel in Galveston Bay, Texas, from Bolivar Channel through Morgan's Cut and the channel constructed through Morgan's Point to the San Jacinto River: Continuing improvement, forty thousand dollars. Galveston Bay, Tex.

Improving harbor at Sabine Pass, Texas: Continuing improvement, three hundred and fifty thousand dollars. Sabine Pass, Tex.

Improving channel in West Galveston Bay, in accordance with plan recommended by Major Charles J. Allen, Corps of Engineers, submitted December twelfth, eighteen hundred and ninety, and printed in House Executive Document Numbered Twenty-two, Fifty-second Congress, first session, fifteen thousand dollars. West Galveston Bay, Tex.

Improving harbor at Ashtabula, Ohio: Continuing improvement, seventy thousand dollars, a portion of which may be used, in the discretion of the Secretary of War, in removing the ledge of rocks on the west side of the river channel inside the mouth. Ashtabula, Ohio. The Secretary of War, is hereby authorized to grant permission, under such regulations and orders as may be prescribed by him, to the Lake Shore and Michigan Southern Railway Company to remove so much of the easterly Government pier at the port of Ashtabula as, in his judgment, may be removed without detriment to the navigation and commerce of the port: *Provided*, That said railway company shall, at its own cost and expense, construct a pier further eastward on its own ground, to answer the purpose of the one removed; the new pier to be constructed under plans to be approved by the Secretary of War. Removal of part of pier. *Proviso.* Construction of new pier. And the space between where the old pier was and the new pier shall be dredged to a depth to be prescribed by the Secretary of War, at the expense of said company, and be maintained at such depth by said company; and the Government of the United States shall, at all times, have the use of said substituted pier for its own vessels free of cost or charges. Use by Government vessels.

Improving harbor at the mouth of Black River, Ohio: Continuing improvement, twenty thousand dollars. Black River, Ohio.

Improving harbor at Cleveland, Ohio: Continuing improvement, one hundred thousand dollars. Cleveland, Ohio.

Improving harbor at Fairport, Ohio: Continuing improvement, thirty-five thousand dollars. Fairport, Ohio.

Improving harbor at Huron, Ohio: Continuing improvement, fifteen thousand dollars. Huron, Ohio.

Improving harbor at Sandusky, Ohio: Completing improvement, forty-one thousand seven hundred and twelve dollars, a part of which may be used, in the discretion of the Secretary of War, in removing shoal at outer approach to harbor. Sandusky, Ohio.

Improving harbor at Toledo—straight channel through Maumee Bay—Ohio: Continuing improvement, two hundred thousand dollars, a part of which may be used, in the discretion of the Secretary of War, in removing shoal in old channel, and in extending the improvement up the Maumee River. Toledo, Ohio.

Improving harbor at Vermillion, Ohio: For repairs and dredging, two thousand dollars. Vermillion, Ohio.

Improving Conneaut Harbor, Ohio: For relocation of channel and construction of new piers (Scheme B, of Engineer's report), forty thousand dollars. Conneaut, Ohio.

Improving harbor at Port Clinton, Ohio: Continuing improvement, ten thousand dollars, of which one thousand two hundred dollars are to be paid to Charles Roose, of Oak Harbor, Ohio, in full satisfaction for the necessary portion of the sand beach adjoining the inner end of the west revetment at Port Clinton Harbor, as recommended by the War Department, and in compliance with the settlement authorized by the act of Congress entitled Port Clinton, Ohio. Charles Roose Payment to

Vol. 24, p. 314. "An act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," approved August fifth, eighteen hundred and eighty-six.

Michigan City, Ind. Improving outer harbor at Michigan City, Indiana: Continuing improvement, thirty thousand dollars.

Improving inner harbor at Michigan City, Indiana: Completing improvement, fifteen thousand dollars.

Calumet, Ill. Improving Calumet Harbor, Illinois: For maintenance of existing works, fifteen thousand dollars.

Chicago, Ill. Improving harbor at Chicago, Illinois: Completing improvement, seventy-two thousand dollars; and the engineer in charge of the harbor is directed, in his next report, to submit what, if any, improvement should be made by the Government in Chicago River, and the cost of same.

Waukegan, Ill. Improving harbor at Waukegan, Illinois: Continuing improvement, twenty-five thousand dollars.

Charlevoix, Mich. Improving harbor at Charlevoix and entrance to Pine Lake, Michigan: Continuing improvement, ten thousand dollars.

Frankfort, Mich. Improving harbor at Frankfort, Michigan: Continuing improvement and repairs, ten thousand dollars.

Grand Haven, Mich. Improving harbor at Grand Haven, Michigan: Continuing improvement, ninety thousand dollars.

Grand Marais, Mich. Improving harbor of refuge at Grand Marais, Michigan: Continuing improvement, thirty thousand dollars.

Manistee, Mich. Improving harbor at Manistee, Michigan: Continuing improvement and for repairs, fifty thousand dollars: *Provided*, That no part of this sum shall be used in aid of the inner navigation until the city authorities, or private owners, have taken proper steps to prevent erosion of the banks and the washing of silt into the bed of the river.

Proviso. Protection of banks.

Holland, Mich. Improving harbor at Holland (Black Lake), Michigan: Continuing improvement, five thousand dollars.

Monroe, Mich. Improving harbor at Monroe, Michigan: Continuing improvement and maintenance, ten thousand dollars.

Muskegon, Mich. Improving harbor at Muskegon, Michigan: Continuing improvement, seventy-five thousand dollars.

Ontonagon, Mich. Improving harbor at Ontonagon, Michigan: Continuing improvement, twenty thousand dollars.

Pentwater, Mich. Improving harbor at Pentwater, Michigan: Continuing improvement, five thousand dollars.

Sand Beach, Mich. Improving harbor of refuge at Sand Beach, Michigan: For repairs, custody, control of harbor, dredging and beginning construction of permanent superstructure, one hundred and fifty thousand dollars.

Saint Joseph, Mich. Improving harbor at Saint Joseph, including Benton Harbor Canal, Michigan: Continuing improvement, sixty thousand dollars, of which one thousand dollars may be expended on the Saint Joseph River, in the discretion of the Secretary of War. The Cincinnati, Wabash and Michigan Railroad Company, owners of the lands abutting on the north side of Saint Joseph River and harbor, shall have the right to load and unload freight over the east three hundred feet of the wing dam or wall constructed at the entrance to Benton Harbor Canal, in the harbor at Saint Joseph, Michigan, under such regulations and orders as may be approved by the Secretary of War; said right to be at any time revocable by him or Congress, after twenty days' notice to said company; and in consideration thereof the said railroad company shall, at their own proper cost and expense, rebuild, repair, renew, and protect the said three hundred feet of wing dam; all such rebuilding, repairs, and renewals to be done under the direction of the Chief of Engineers of the United States Army.

Use of dam.

South Haven, Mich. Improving harbor at South Haven, Michigan; Continuing improvement ten thousand dollars.

White Lake, Mich. Improving harbor at White Lake, Michigan: Continuing improvement, five thousand dollars.

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Improving harbor at Marquette, Michigan: Continuing improvement, eighty thousand dollars. Marquette, Mich.

Improving harbor at Ludington, Michigan: Continuing improvements, five thousand dollars. Ludington, Mich.

Improving harbor at Petosky, Michigan: Continuing improvement, twenty thousand dollars, which amount, together with the sum appropriated for this harbor in the act of September nineteenth, eighteen hundred and ninety, shall be used in the improvement of the harbor according to the plans for the smaller of the two projects submitted in the report of December twenty-first, eighteen hundred and eighty-nine, and printed in the annual report for eighteen hundred and ninety, pages twenty-six hundred and seventy-four and twenty-six hundred and seventy-five. Petosky, Mich. Vol. 26, p. 433.

Improving harbor at Saugatuck, Michigan: Continuing improvement, five thousand dollars. Saugatuck, Mich.

Improving harbor at Ahnapee, Wisconsin: Continuing improvement, seven thousand dollars. Ahnapee, Wis.

Improving harbor at Green Bay, Wisconsin, twenty-five thousand dollars, to be expended on the existing project and in securing a sixteen-foot channel, in accordance with the recommendation of Major James F. Gregory, Corps of Engineers, submitted under date of February twelfth, eighteen hundred and ninety-two: *Provided*, That five thousand dollars of said sum may, in the discretion of the Secretary of War, be expended on the Fox River, below De Pere, Wisconsin. Green Bay, Wis. *Proviso.* Fox River.

Improving harbor at Kenosha, Wisconsin: Continuing improvement, fifteen thousand dollars, not exceeding two thousand five hundred dollars of which may be expended in dredging the inner harbor. Kenosha, Wis.

Improving harbor at Kewaunee, Wisconsin: Continuing improvement, thirty thousand dollars. Kewaunee, Wis.

Improving harbor at Manitowoc, Wisconsin: Continuing improvement, and maintenance, twenty-eight thousand dollars. Manitowoc, Wis.

Improving harbor of refuge at Milwaukee, Wisconsin: Continuing improvement, seventy-five thousand dollars. Milwaukee, Wis.

Improving harbor at Milwaukee, Wisconsin: Completing improvement, fourteen thousand dollars. Milwaukee, Wis.

Improving harbor at Port Washington, Wisconsin: Completing improvement, six thousand five hundred dollars. Port Washington, Wis.

Improving harbor at Racine, Wisconsin: Continuing improvement, twenty-five thousand dollars. Racine, Wis.

Improving harbor at Superior Bay and Saint Louis Bay, Wisconsin: Continuing improvement, seventy thousand dollars, a portion of which may, in the discretion of the Secretary of War, be used in dredging in Superior Bay along the dock line between the Quebec Channel and the main channel opposite the base of Connor's Point. Superior and Saint Louis bays, Wis.

Improving harbor at Sheboygan, Wisconsin: Continuing improvement, twenty-five thousand dollars. Sheboygan, Wis.

Improving harbor at Ashland, Wisconsin: Continuing improvement, forty-five thousand dollars. Ashland, Wis.

Improving harbor at Two Rivers, Wisconsin: Continuing improvement, three thousand dollars. Two Rivers, Wis.

Improving harbor of refuge at Sturgeon Bay Canal, Wisconsin: For maintenance of channel and piers, five thousand dollars. Sturgeon Bay Canal, Wis.

Improving harbor at Oconto, Wisconsin: To maintain works, three thousand dollars. Oconto, Wis.

Improving harbor at Duluth, Minnesota, including repairs to the canal, piers, the channel on the north shore of Saint Louis Bay, and the Saint Louis River, one hundred and twenty-five thousand dollars, of which forty-five thousand dollars, or so much thereof as may be necessary, may be used, in the discretion of the Secretary of War, in the channel of Saint Louis River above Grassy Point. And the Secretary of War is hereby directed to cause an investigation to be made into the question of ownership of the ground on which is located the canal, canal entrances, and piers in this har- Duluth, Minn. Investigation of title to land occupied by canal, etc.

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bor, with the view of determining whether the grant and conveyance made by the city of Duluth, dated January ninth, eighteen hundred and eighty-eight, to the United States, and accepted by the United States in the river and harbor act of August eleventh, eighteen hundred and eighty-eight, covers the same in full, and make report thereof to Congress, and should it appear that a portion of the ground on which is located said canal, canal entrances, and piers has not yet been vested in the United States, to make such recommendations as may be necessary to the end that all the ground pertaining to said canal, canal entrances, and piers may become the property of the United States.

Vol. 25. p. 407.

Grand Marais, Minn.

Improving harbor at Grand Marais, Minnesota: Continuing improvement, ten thousand dollars.

Agate Bay, Minn.

Improving harbor at Agate Bay, Minnesota: Continuing improvement, thirty thousand dollars.

Humboldt, Cal.

Improving harbor and bay at Humboldt, California: Continuing improvement, one hundred and fifty thousand dollars: *Provided*, That contracts may be entered into by the Secretary of War for such materials and work as may be necessary to complete the present project of improvement, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate one million five hundred and sixty-five thousand one hundred and fifteen dollars, exclusive of the amount herein and heretofore appropriated.

Proviso.

Contracts.

Limit.

Oakland, Cal.

Improving harbor at Oakland, California: Continuing improvement, one hundred and fifty thousand dollars.

Wilmington, Cal.

Improving harbor at Wilmington, California: Completing improvement, fifty-one thousand dollars.

San Diego, Cal.

Improving harbor at San Diego, California: Continuing improvement, fifty thousand dollars.

San Luis Obispo, Cal.

Improving harbor at San Luis Obispo, California: Continuing improvement, thirty thousand dollars.

Examination for deep-water harbor, San Pedro or Santa Monica, Cal., to be made.

The Secretary of War is hereby authorized and directed to appoint a board of five engineer officers of the United States Army, whose duty it shall be to make a careful and critical examination for a proposed deep-water harbor at San Pedro or Santa Monica bays, and to report as to which is the more eligible location for such harbor in depth, width, and capacity to accommodate the largest ocean-going vessils and the commercial and naval necessities of the country, together with an estimate of the cost. Said board of engineers shall report the result of its investigations to the Secretary of War on or before the first of November, eighteen hundred and ninety-two; and ten thousand dollars, or so much thereof as may be necessary, are hereby appropriated for said purpose.

Report.

Coos Bay, Oregon.

Improving entrance and harbor at Coos Bay, Oregon: Continuing improvement, two hundred and ten thousand dollars.

Yaquina Bay, Oregon.

Improving harbor at Yaquina Bay, Oregon: Continuing improvement, eighty-five thousand dollars.

Tillamook Bay, Oregon.

Improving Tillamook Bay, Oregon, fifteen thousand dollars.

Grays Harbor, Chehalis River, Wash.

Improving Grays Harbor and Chehalis River, Washington, fifty thousand dollars.

Olympia, Wash.

Improving Olympia Harbor, Washington, thirty-five thousand dollars.

Rivers.

Bagaduce River, Me.

Improving Bagaduce River, Maine: Continuing improvements, five thousand dollars.

Kennebec River, Me.

Improving Kennebec River, Maine: Continuing improvement, one hundred thousand dollars, of which not exceeding five thousand dollars may, in the discretion of the Secretary of War, be expended between the cities of Augusta and Waterville.

Narraguagus River, Me.

Improving Narraguagus River, Maine: Continuing improvement, seven thousand five hundred dollars.

Penobscot River, Me.

Improving Penobscot River, Maine: Continuing improvement, forty thousand dollars.

Saco River, Me.

Improving Saco River, Maine, including breakwater: Continuing improvement, twenty-five thousand dollars.

Harraseeket River, Me.

Improving Harraseeket River, Maine: Completing improvement, sixteen thousand dollars.

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Improving Bellamy River, New Hampshire: Continuing improvement, seven thousand five hundred dollars. Bellamy River, N. H.

Improving Cocheco River, New Hampshire: Continuing improvement, fifteen thousand dollars. Cocheco River, N. H.

Improving Otter Creek, Vermont: Completing improvement, ten thousand dollars. Otter Creek, Vt.

Improving Powow River, Massachusetts: Continuing improvement, four thousand dollars. Powow River, Mass.

Improving Taunton River, Massachusetts: Completing improvement, seven thousand dollars. Taunton River, Mass.

Improving Merrimac River, Massachusetts: Completing improvement, one thousand five hundred dollars: *Provided*, That the amount appropriated in act of September nineteenth, eighteen hundred and ninety, for improving Merrimac River at Mitchell's Falls, may be applied to the general improvement of the river in the discretion of the Secretary of War. Merrimac River, Mass. *Proviso.* Reappropriation. Vol. 26, p. 436.

Improving Ipswich River, Massachusetts: Continuing improvement, two thousand five hundred dollars. Ipswich River, Mass.

Improving Weymouth River, Massachusetts: Continuing improvement, ten thousand dollars. Weymouth River, Mass.

Improving Mystic and Malden rivers, Massachusetts, ten thousand dollars. Mystic and Malden rivers, Mass.

Improving Essex River, Massachusetts, five thousand dollars. Essex River, Mass.

Improving Pawtucket River, Rhode Island: Continuing improvement, thirty-five thousand dollars. Pawtucket River, R. I.

Improving Providence River and Narragansett Bay, Rhode Island: Continuing improvement, fifty thousand dollars. Providence River and Narragansett Bay, R. I.

Improving Green Jacket Shoal, Providence River, Rhode Island: Continuing improvement, ten thousand dollars. Green Jacket Shoal, R. I.

Improving Pawcatuck River, Rhode Island: Completing improvement, three thousand eight hundred dollars. Pawcatuck River, R. I.

Improving Connecticut River below Hartford, Connecticut: Continuing improvement, twenty thousand dollars. Connecticut River, Conn.

Improving Housatonic River, Connecticut: Continuing improvement, twenty thousand dollars. Housatonic River, Conn.

Improving Thames River, Connecticut: Continuing improvement, thirty thousand dollars, of which ten thousand dollars may, in the discretion of the Secretary of War, be applied for improvement in that portion of New London Harbor known as Shaw's Cove. Thames River, Conn.

Improving Mystic River, Connecticut: Continuing improvement, ten thousand dollars. Mystic River, Conn.

Improving Saugatuck River, Connecticut: seven thousand dollars to be expended in the improvement of the natural channel. Saugatuck River, Conn.

Improving Hudson River, New York, by extension of project of improvement adopted in eighteen hundred and sixty-seven, so as to provide for a channel twelve feet deep and four hundred feet wide from Coxsackie to the foot of Broadway, Troy, and thence twelve feet deep and three hundred feet wide to the State dam at Troy, one hundred and eighty-seven thousand five hundred dollars: *Provided*, That contracts may be entered into by the Secretary of War for such materials and work as may be necessary to carry out the plan recommended by Board of Engineers, United States Army, dated October first, eighteen hundred and ninety-one, and printed in House Executive Document Numbered Twenty-three, Fifty-second Congress, first session, for the improvement of the Hudson River, as above stated, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate two million two hundred and sixty thousand four hundred and six dollars, exclusive of the amount herein and heretofore appropriated. Hudson River, N. Y. Coxsackie to Troy dam. *Proviso.* Contracts. Limit.

Improving Newtown Creek and Bay, New York: Continuing improvement, thirty-five thousand dollars. Newtown Creek and Bay, N. Y.

Improving Harlem River, New York: Continuing improvement, one hundred and seventy-five thousand dollars. Harlem River, N. Y.

Improving East River and Hell Gate, New York: Removing obstructions, one hundred and fifty thousand dollars. East River and Hell Gate, N. Y.

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Browns Creek, N. Y. — Improving Brown's Creek, Sayville, Long Island, New York: Continuing improvement, five thousand dollars.

Great Chazy River, N. Y. — Improving Great Chazy River, New York: Continuing improvement, five thousand dollars.

Lake Champlain Narrows, N. Y. — Improving narrows at Lake Champlain, New York: To complete improvement, eighteen thousand five hundred dollars.

Saint Lawrence River, N. Y. — Improving shoal between Sister Islands and Cross-Over Light, Saint Lawrence River, New York: Continuing improvement, ten thousand dollars.

Patchogue River, N. Y. — Improving Patchogue River, New York: Continuing improvement, eight thousand dollars.

Niagara River, N. Y. — Improving Niagara River, from Tonawanda to Port Day, New York, to secure channel eight feet deep at mean lake level, twenty thousand dollars.

Passaic River, N. J. — Improving Passaic River, New Jersey: Continuing improvement, forty-five thousand dollars.

Raritan River, N. J. — Improving Raritan River, New Jersey: Continuing improvement, forty thousand dollars.

Shrewsbury River, N. J. — Improving Shrewsbury River, New Jersey: Continuing improvement, ten thousand dollars.

South River, N. J. — Improving South River, New Jersey: Continuing improvement, seven thousand dollars.

Alloway Creek, N. J. — Improving Alloway Creek, New Jersey: Continuing improvement, three thousand dollars.

Elizabeth River, N. J. — Improving Elizabeth River, New Jersey: Continuing improvement, five thousand dollars.

Mattawan Creek, N. J. — Improving Mattawan Creek, New Jersey: Completing improvement, nine thousand six hundred and twenty dollars.

Rancocas River, N. J. — Improving Rancocas River, New Jersey: Continuing improvement, five thousand dollars.

Shoal Harbor and Compton Creek, N. J. — Improving Shoal Harbor and Compton Creek, New Jersey: Continuing improvement, three thousand dollars.

Goshen Creek, N. J. — Improving Goshen Creek, New Jersey, three thousand dollars.

Salem River, N. J. — Improving Salem River, New Jersey, two thousand five hundred dollars, to be expended above the canal.

Allegheny River, Pa. — Improving Allegheny River, Pennsylvania: Continuing improvement, twenty-five thousand dollars.

Schuylkill River, Pa. — Improving Schuylkill River, Pennsylvania: Completing improvement, forty-six thousand two hundred and fifty dollars.

Delaware River, Pa. and N. J. — Improving Delaware River from Trenton to its mouth, Pennsylvania and New Jersey: Continuing improvement, fifty thousand dollars.

Herr's Island Dam, Allegheny River, Pa. — For continuing construction of dam at Herr's Island, Allegheny River, Pennsylvania, forty thousand dollars.

Appoquinimink River, Del. — Improving Appoquinimink River, Delaware: Continuing improvement, five thousand dollars.

Smyrna River, Del. — Improving Smyrna River, Delaware: Continuing improvement, three thousand dollars.

Murderkill River, Del. — Improving Murderkill River, Delaware; seven thousand dollars.

Broad Creek River, Del. — Improving Broad Creek River, Delaware, five thousand dollars.

Mispillion River, Del. — Improving Mispillion River, Delaware, according to project recommended by William F. Smith, United States agent, in his letter of November fifth, eighteen hundred and ninety-one, to the Chief of Engineers, United States Army, twelve thousand dollars.

Inland waterway, Delaware and Chincoteague bays. — Improving the inland water way from Chincoteague Bay, Virginia, to Delaware Bay at or near Lewes, to be used from Delaware Bay to Indian River: Continuing improvement, twenty-five thousand dollars: *Proviso.* *Provided*, That no part of this appropriation shall be expended until the right of way is secured without cost to the United States. Right of way.

Choptank River, Md. — Improving Choptank River, Maryland: Continuing improvement, three thousand dollars.

Susquehanna River, Md. and Pa. — Improving Susquehanna River, Maryland and Pennsylvania: Continuing improvement, four thousand dollars, to be expended above Havre de Grace.

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Improving Chester River, Maryland: Continuing improvement three thousand dollars. Chester River, Md.

Improving Elk River, Maryland: Continuing improvement, five thousand dollars. Elk River, Md.

Improving Manokin River, Maryland: Continuing improvement, seven thousand five hundred dollars. Manokin River, Md.

Improving Northeast River, Maryland: Completing improvement, two thousand six hundred and forty dollars. Northeast River, Md.

Improving Wicomico River, Maryland: Continuing improvement, six thousand five hundred dollars. Wicomico River, Md.

Improving Patapsco River, Baltimore Harbor, Maryland: For dredging a channel one hundred and fifty feet wide at bottom and of a depth of twenty-seven feet mean low water from the main ship channel to Curtis Bay, in accordance with recommendation of Colonel William P. Craighill, Corps of Engineers, submitted December thirteenth, eighteen hundred and ninety, twenty-eight thousand dollars. Patapsco River, Md., Baltimore Harbor.

Improving Warwick River, Maryland: In accordance with recommendation of United States Agent W. F. Smith, submitted August seventeenth, eighteen hundred and ninety-one, six thousand dollars. Warwick River, Md.

Improving Latrappe River, Maryland, in accordance with recommendation of United States Agent W. F. Smith, submitted July thirtieth, eighteen hundred and ninety-one, two thousand five hundred dollars. Latrappe River, Md.

Improving Potomac River, Washington, District of Columbia: Continuing improvement, two hundred thousand dollars. Potomac River, D. C.

Improving Appomattox River, Virginia: Completing improvement, fifteen thousand and eighty dollars. Appomattox River, Va.

Improving Nansemond River, Virginia: Continuing improvement, ten thousand dollars. Nansemond River, Va.

Improving Chickahominy River, Virginia: Completing improvement, five thousand dollars. Chickahominy River, Va.

Improving James River, Virginia: Continuing improvement, two hundred thousand dollars. James River, Va.

Improving Mattaponi River, Virginia: Continuing improvement, four thousand dollars, of which one thousand five hundred dollars shall be expended between Aylett's and Guinea's bridges. Mattaponi River, Va.

Improving Nomini Creek, Virginia: Continuing improvement, ten thousand dollars. Nomini Creek, Va.

Improving Pamunkey River, Virginia: Continuing improvement, three thousand dollars. Pamunkey River, Va.

Improving Rappahannock River, Virginia: Continuing improvement, twenty thousand dollars. Rappahannock River, Va.

Improving Urbanna Creek, Virginia: Continuing improvement, three thousand dollars. Urbanna Creek, Va.

Improving York River, Virginia: Continuing improvement, thirty-five thousand dollars. York River, Va.

Improving Aquia Creek, Virginia: Continuing improvement, five thousand dollars. Aquia Creek, Va.

Improving Occoquan Creek, Virginia: Continuing improvement, five thousand dollars. Occoquan Creek, Va.

Improving Lower Machodoc Creek, Virginia, three thousand dollars. Lower Machodoc Creek, Va.

Improving Elk River, West Virginia, two thousand five hundred dollars. Elk River, W. Va.

Improving Great Kanawha River, West Virginia; continuing improvement, two hundred and twenty-five thousand dollars: *Provided*, That contracts may be entered into by the Secretary of War for such materials and work as may be necessary to complete the revised project of improvement of January eighth, eighteen hundred and ninety-two, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate one million eighty thousand seven hundred dollars, exclusive of the amount herein and heretofore appropriated. Great Kanawha River, W. Va. *Proviso.* Contracts. Limit.

Improving Guyandotte River, West Virginia: For maintenance, two thousand dollars. Guyandotte River, W. Va.

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Gauley River, W. Va. Improving Gauley River, West Virginia: Continuing improvement, three thousand dollars.

Monongahela River, W. Va. Improving Monongahela River, West Virginia: Continuing improvement, twenty-five thousand dollars, for beginning work on lock and dam number ten.

Water way, Beaufort to New River, N. C. Improving inland water way between Beaufort Harbor and New River, North Carolina: Continuing improvement, ten thousand dollars.

Lockwoods Folly River, N. C. Improving Lockwoods Folly River, North Carolina: Continuing improvement, three thousand dollars.

North East (Cape Fear) River, N. C. Improving North East (Cape Fear) River, North Carolina: Continuing improvement, five thousand dollars.

Ocracoke Inlet, N. C. Improving Ocracoke Inlet, North Carolina: Continuing improvement, fifteen thousand dollars.

Pasquotank River, N. C. Improving Pasquotank River, North Carolina: continuing improvement, three thousand dollars.

Cape Fear River, N. C. Improving Cape Fear River, North Carolina, above Wilmington: Continuing improvement, fifteen thousand dollars,

Improving Cape Fear River, North Carolina, at and below Wilmington: Continuing improvement, two hundred thousand dollars.

Contentnia Creek, N. C. Improving Contentnia Creek, North Carolina: Continuing improvement, seven thousand dollars.

Neuse River. N. C. Improving Neuse River, North Carolina: Continuing improvement, fifteen thousand dollars.

New River, N. C. Improving New River, North Carolina: Continuing improvement, five thousand dollars.

Pamlico and Tar Rivers, N. C. Improving Pamlico and Tar Rivers, North Carolina: Continuing improvement, ten thousand dollars.

Roanoke River, N. C. Improving Roanoke River, North Carolina: Continuing improvement, fifty thousand dollars.

Trent River, N. C. Improving Trent River, North Carolina: Continuing improvement, five thousand dollars.

Yadkin River, N. C. Improving Yadkin River, North Carolina: Completing improvement, five thousand dollars.

Lumber River, N. C. and S. C. Improving Lumber River, North and South Carolina: Continuing improvement, five thousand dollars.

Fishing Creek, N. C. Vol. 26, p. 441. Improving Fishing Creek, North Carolina: Continuing improvement, five thousand dollars, and a former appropriation of ten thousand dollars, together with this, may be expended whenever draws are provided in such bridges as are, in the opinion of the engineer in charge, unreasonable obstructions to navigation.

Block River, N. C. Improving Block River, North Carolina: Continuing improvement, ten thousand dollars.

Water way, Norfolk, Va., to Albemarle Sound, N. C. Improving inland water route from Norfolk Harbor, Virginia, to Albemarle Sound, North Carolina, through Currituck Sound: Continuing improvement, nine thousand dollars.

Edisto River, S. C. Improving Edisto River, South Carolina: Completing improvement, seven thousand three hundred and eighty-five dollars.

Great Peedee River, S. C. Improving Great Peedee River, South Carolina: Continuing improvement, ten thousand dollars.

Santee River, S. C. Improving Santee River, South Carolina: Continuing improvement, thirty thousand dollars, to be used in snagging and in making new cut between Estherville and Minim Creek.

Waccamaw River, N. C. and S. C. Improving Waccamaw River, North and South Carolina: Continuing improvement, ten thousand dollars.

Wappoo cut, S. C. Improving Wappoo cut, South Carolina: Continuing improvement, ten thousand dollars.

Wateree River, S. C. Improving Wateree River, South Carolina: For maintenance, two thousand five hundred dollars.

Congaree River, S. C. Improving Congaree River, South Carolina: Continuing improvement, five thousand dollars.

Mingo Creek, S. C. Improving Mingo Creek, South Carolina: Continuing improvement, three thousand dollars.

Little Peedee River, S. C. Improving Little Peedee River, South Carolina: Continuing improvement, five thousand dollars.

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Improving Clark River, South Carolina: Completing improvement, two thousand five hundred dollars. Clark River, S. C.

Improving Beaufort River, South Carolina: Completing improvement, twelve thousand five hundred dollars. Beaufort River, S. C.

Improving Altamaha River, Georgia: Continuing improvement, fifteen thousand dollars. Altamaha River, Ga.

Improving Chattahoochee River, Georgia and Alabama: Continuing improvement, twenty-five thousand dollars, of which five thousand dollars are to be used on that portion of the river between West Point and Franklin. Chattahoochee River, Ga. and Ala.

Improving Flint River, Georgia: Continuing improvement, fifteen thousand dollars, of which four thousand dollars are to be expended between Albany and Montezuma, and eleven thousand below Albany. Flint River, Ga.

Improving Ocmulgee River, Georgia: Continuing improvement, twenty-five thousand dollars, of which twelve thousand five hundred dollars are to be expended between Macon and Hawkinsville, and the like sum below Hawkinsville. Ocmulgee River, Ga.

Improving Oconee River, Georgia: Continuing improement, twenty-five thousand dollars, of which five thousand dollars are to be expended between Milledgeville and the Central Railroad bridge. Oconee River, Ga.

Improving Savannah River, between Augusta and Savannah: Continuing improvement, thirty-five thousand dollars. Savannah River, Ga. Augusta to Savannah.

Improving Jekyl Creek, Georgia: Continuing improvement, seven thousand five hundred dollars. Jekyl Creek, Ga.

Improving Coosa River in Georgia and Alabama, between Rome, Georgia, and the East Tennessee, Virginia and Georgia Railroad bridge in Alabama: Continuing improvement, one hundred and thirty thousand dollars. Coosa River, Ga. and Ala.

Improving Coosa River between Wetumpka, Alabama and the East Tenneśsee, Virginia and Georgia Railroad bridge: Continuing improvement, one hundred thousand dollars, and the restriction as to the size of the locks to be constructed on the Coosa River, placed in the river and harbor act of September nineteenth, eighteen hundred and ninety, is hereby repealed. Coosa River, Ala. Locks. Vol. 26, p. 442.

Inside water route between Savannah, Georgia, and Fernandina, Florida, fifteen thousand dollars. Water way. Savannah, Ga., to Fernandina, Fla.

Improving Savannah River, Georgia, above Augusta, ten thousand dollars. Savannah River, Ga., above Augusta.

Improving Apalachicola River, Florida, including Lee's Slough and its connection with the Chipola River, and from said connection to the mouth of the Chipola River: Continuing improvement, five thousand dollars. Apalachicola River, Fla.

Improving Caloosahatchee River, Florida: For maintenance, one thousand dollars. Caloosahatchee River, Fla.

Improving Choctawhatchee River, Florida, and Alabama: Continuing improvement, twelve thousand five hundred dollars: *Provided*, That no part of said sum shall be expended above Hollis Bridge until a draw approved by the Secretary of War is put in said bridge. Choctawhatchee River, Fla. and Ala. *Proviso.* Drawbridge.

Improving Escambia and Conecuh Rivers, Florida: Continuing improvement, eight thousand dollars, of which three thousand dollars are for snag boat and five thousand dollars for operating the same. Escambia and Conecuh rivers, Fla.

Improving Manatee River, Florida: Continuing improvement, six thousand dollars. Manatee River, Fla.

Improving the channel over the bar at the mouth of the Saint Johns River, Florida: Continuing improvement, one hundred and twelve thousand five hundred dollars: *Provided*, That contracts may be entered into by the Secretary of War for such materials and work as may be necessary to carry out the project of June eleventh, eighteen hundred and ninety-one, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate two hundred and eighty-four thousand five hundred dollars, exclusive of the amount herein and heretofore appropriated. Saint Johns River, Fla. *Proviso.* Contracts. Limit.

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Suwanee River, Fla. Improving Suwanee River, Florida: Continuing improvement, three thousand dollars.

Volusia Bar, Fla. Improving Volusia Bar, Florida: For repairs, one thousand dollars.

Ocklawaha River, Fla. Improving Ocklawaha River, Florida: For maintenance, one thousand dollars.

Sarasota Bay, Fla. Improving Sarasota Bay, Florida: Continuing improvement, two thousand five hundred dollars.

Indian River, Fla. *Proviso.* Improving Indian River, Florida, between Goat Creek and Jupiter Inlet, fifteen thousand dollars: *Provided*, That no part of the money hereby appropriated shall be expended until the Florida Coast Line Canal and Transportation Company surrenders and relinquishes to the United States all the rights and privileges which it now holds under State charter along the entire route.

Alabama River, Ala. Improving Alabama River, Alabama: Continuing improvement, seventy thousand dollars.

Black Warrior River, Ala. Improving Black Warrior River, Alabama, from Tuscaloosa to Daniels Creek: Continuing improvement, two hundred thousand dollars.

Cahaba River, Ala. improving Cahaba River, Alabama: Continuing improvement, seven thousand five hundred dollars.

Tombigbee and Warrior Rivers, Ala. Improving Tombigbee and Warrior Rivers, Alabama, from mouth of Tombigbee River to Tuscaloosa: Continuing improvement, two hundred thousand dollars, of which one hundred and twenty-five thousand dollars are to be expended on the Tombigbee River and seventy-five thousand dollars on the Warrior River, and so much of said sums as may be necessary is authorized to be expended in acquiring by purchase or condemnation, under the laws of Alabama, the lands needed in making such improvements.

Tombigbee River, Ala. Improving Tombigbee River from Fulton to Columbus: Continuing improvement, six thousand dollars.

Improving Tombigbee River, from Demopolis, Alabama, to Columbus, Mississippi: Continuing improvement, thirty-five thousand dollars.

Improving Tombigbee River, from Walker's Bridge to Fulton: Continuing improvement, three thousand dollars.

Big Sunflower River, Miss. Improving Big Sunflower River, Mississippi: Continuing improvement, five thousand dollars.

Noxubee River, Miss. Improving Noxubee River, Mississippi: For maintenance, three thousand dollars.

Pascagoula River, Miss. Improving Pascagoula River, Mississippi: Continuing improvement, twenty thousand dollars.

Pearl River, Miss. Improving Pearl River, Mississippi, between Edinburg and Carthage: For maintenance, five hundred dollars.

Improving Pearl River, Mississippi, between Carthage and Jackson: Continuing improvement, five thousand dollars.

Improving Pearl River, Mississippi, below Jackson: Continuing improvement, fifteen thousand dollars.

Steele's Bayou, Miss. Improving Steele's Bayou, Mississippi: Continuing improvement, two thousand five hundred dollars.

Tchula Lake, Miss. Improving Tchula Lake, Mississippi: Continuing improvement, three thousand dollars.

Yazoo River, Miss. Improving Yazoo River, Mississippi: Continuing improvement, twenty thousand dollars.

Tallahatchee, River, Miss. Improving Tallahatchee River, Mississippi: Continuing improvement, five thousand dollars, of which amount two thousand dollars may be used in the improvement of said river between the bridge at Panola, Mississippi and the mouth of the Coldwater River at the discretion of the Secretary of War.

Leaf River, Miss. Improving Leaf River, Mississippi, from its mouth to Bowie Creek: Continuing improvement, five thousand dollars.

Big Black River, Miss. Improving Big Black River, Mississippi: Continuing improvement, five thousand dollars.

Chickasahay River, Miss. Improving Chickasahay River, Mississippi, from the mouth up to railroad bridge near Shubuta: Continuing improvement, five thousand dollars.

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Improving mouth of the Yazoo River, Mississippi, in accordance with plan of Captain J. H. Williard, Corps of Engineers, United States Army, dated February fourth, eighteen hundred and ninety-two, contained in House Executive Document numbered One hundred and twenty-five, Fifty-second Congress, first session, including borings and gauges, seventy-five thousand dollars; and should the Secretary of War be unable to obtain such right of way as may be necessary in the prosecution of this work, upon reasonable terms, by agreement, purchase, or voluntary conveyance, he is hereby authorized to apply at any term of the circuit or district court of the United States for the western division of the southern district of Mississippi, and in the name of the United States institute and carry on proceedings to condemn such lands as may be necessary for right of way as aforesaid and in such proceedings said court shall be governed by the laws of the State of Mississippi so far as the same may be applicable to the subject of condemning private property for public use. Yazoo River, Miss., mouth of. Right of way. Condemnation.

Improving Amite River and Bayou Manchac, Louisiana: For maintenance, two thousand five hundred dollars, of which one thousaud dollars may be used to construct a turning basin for boats at or near the mouth of Ward's Creek on Bayou Manchac. Amite River and Bayou Manchac, La.

Improving Bœuf River, Louisiana: Continuing improvement, ten thousand dollars. Bœuf River, La.

Improving Bayou Bartholomew, Louisiana and Arkansas: Continuing improvement, five thousand dollars. Bayou Bartholomew, La. and Ark.

Improving Bayou D'Arbonne, Louisiana: Completing improvement, four thousand dollars; one thousand dollars of which shall be expended in improvement of the Cornie from Steins Bluff to the head of navigation on said stream. Bayou D'Arbonne, La.

Improving Tensas River and Bayou Macon, Louisiana and Arkansas: Continuing improvement, five thousand dollars. Tensas River and Bayou Macon, La. and Ark.

Improving Red River, Louisiana and Arkansas, from Fulton, Arkansas, to the Atchafalaya River: Continuing improvement, according to plan of Captain J. H. Willard, Corps of Engineers, United States Army, and for completion of survey, including the work at Alexandria, the widening of that portion of the river known as Little River, the necessary work at the harbor of Shreveport, the closing of outlets on the west bank of the river above Shreveport, and the removal of the "tow head" just above Rush Point, in Caddo Parish, one hundred and forty-five thousand dollars, of which five thousand dollars may be used, in the discretion of the Secretary of War, for work in Cypress Bayou and the lakes between Shreveport, Louisiana, and Jefferson, Texas. Red River, Ark and La.

Improving Tickfaw River, Louisiana: For maintenance, one thousand dollars. Tickfaw River, La.

Improving Bayou Plaquemine, Louisiana: Continuing improvement, one hundred and fifty thousand dollars, of which sum not exceeding ten thousand dollars may be used, in the discretion of the Secretary of War, in removing obstructions from Grand River and Pigeon bayous, forming part of the Bayou Plaquemine route. Bayou Plaquemine, La.

Improving Bayou Lafourche, Louisiana: Continuing improvement and removing obstructions, fifty thousand dollars. Bayou Lafourche, La.

Improving Tchefuncte River and Bogue Falia, Louisiana: For maintenance, one thousand dollars. Tchefuncte River and Bogue Falia, La.

Improving Bogue Chitto, Louisiana: Continuing improvement, five thousand dollars. Bogue Chitto, La.

Improving the channel, bay, and passes of Bayou Vermillion, Louisiana, seven thousand five hundred dollars. Bayou Vermillion, La.

Improving Mermentau River and tributaries, Louisiana, seven thousand five hundred dollars. Mermentau River, La.

Improving Buffalo Bayou, Texas: Continuing improvement, twenty-five thousand dollars. Buffalo Bayou, Tex.

Improving Trinity River, Texas: Continuing improvement, ten thousand dollars. Trinity River, Tex.

Improving Cedar Bayou, Texas: Completing improvement, fourteen thousand dollars. Cedar Bayou, Tex.

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Cypress Bayou and Lakes, Tex. Improving Cypress Bayou and Lakes, Texas and Louisiana: Completing survey, two thousand dollars.

Sabine River, Tex. Improving Sabine River, up to Sudduth's Bluff, Texas, five thousand dollars.

Arkansas River, Ark. and Ind. T. Improving Arkansas River, Arkansas and Indian Territory, two hundred and fifty thousand dollars, two-fifths of which amount shall be expended from the mouth of the river to Little Rock, two-fifths from Little Rock to Fort Smith, and one-fifth above Fort Smith.

Saint Francis River, Ark. Improving Saint Francis River, Arkansas: Continuing improvement, eight thousand dollars.

Arkansas River. Improving Arkansas River: Removing obstructions and operating snag boats, twenty thousand dollars.

Black River, Ark. and Mo. Improving Black River, Arkansas and Missouri: Continuing improvement, five thousand dollars.

Petit Jean River, Ark. Improving Petit Jean River, Arkansas: Completing improvement, three thousand five hundred dollars.

White River, Ark. Improving White River, Arkansas: Continuing improvement, seventy-five thousand dollars, fifty-three thousand eight hundred and fifteen dollars of which shall be used for completion of the existing project, the remainder to be expended in the discretion of the Secretary of War.

Ouachita and Black Rivers, Ark. and La. Improving Ouachita and Black Rivers, Arkansas and Louisiana: Continuing improvement, forty thousand dollars, of which not exceeding five thousand dollars may be used, in the discretion of the Secretary of War, at the harbor of Camden, Arkansas.

Red River, Ark. Improving Red River, above Fulton, Arkansas: Continuing improvement, three thousand five hundred dollars.

Cache River, Ark. Improving Cache River, Arkansas: Continuing improvement, two thousand dollars.

Big Hatchee River, Tenn. Improving Big Hatchee River, Tennessee: Continuing improvement, three thousand five hundred dollars.

Clinch River, Tenn. Improving Clinch River, Tennessee: Continuing improvement, four thousand dollars.

Cumberland River, Tenn. and Ky.

Above Nashville. Improving Cumberland River, Tennessee and Kentucky: Continuing improvement above Nashville, two hundred and fifty thousand dollars, of which five thousand dollars may be used, in the discretion of the Secretary of War, in the improvement of the river above the town of Burnside.

Below Nashville. Improving Cumberland River, Tennessee, below Nashville: Continuing improvement, including the work at the mouth of the river, forty thousand dollars: *Provided*, That ten thousand dollars of this sum, or so much thereof as may be necessary, shall be available for acquiring site and locating lock and dam near the mouth of Harpeth River, Tennessee, according to the survey and plan of Lieutenant-Colonel Barlow, Corps of Engineers, United States Army, submitted in December, eighteen hundred and eighty-nine.

Proviso.

Lock and dam.

French Broad River, Tenn. Improving French Broad River, Tennessee: Continuing improvement, fifteen thousand dollars, of which one thousand dollars may be used in removing the bar or shoal in Little Pigeon River, a tributary of the French Broad River.

Forked Deer River, Tenn. Improving Forked Deer River, Tennessee: Completeing improvement, three thousand dollars.

Tennessee River.

Below Chattanooga, Tenn. Improving Tennessee River, below Chattanooga, Tennessee: Continuing improvement, five hundred thousand dollars, of which twenty-five thousand dollars may be used in continuing the work at Livingston Point, Kentucky.

Above Chattanooga. Improving Tennessee River, above Chattanooga Tennessee: Continuing improvement, twenty-five thousand dollars.

Obion River, Tenn. Improving Obion River, Tennessee, from its mouth to the crossing of the Louisville and Memphis Railroad in Obion County, seven thousand five hundred dollars.

Kentucky River, Ky. Improving Kentucky River, Kentucky: Continuing improvement, one hundred and fifty thousand dollars.

Ohio River, Ky. Improving the falls of the Ohio River, Kentucky: Continuing improvement, sixty thousand dollars.

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Improving Indiana Chute Fall, Ohio River: Continuing improvement, thirty-five thousand dollars. Indiana Chute Fall.

Improving Rough River, Kentucky: Continuing improvement, fifteen thousand dollars. Rough River, Ky.

Improving Levisa Fork, Big Sandy River, Kentucky: For maintenance, two thousand five hundred dollars. Levisa Fork, Big Sandy River, Ky.

Improving Tug Fork, Big Sandy River, Kentucky: For maintenance, two thousand five hundred dollars. Tug Fork, Big Sandy River, Ky.

Improving Big Sandy River, near Louisa, Kentucky: For movable dam in lieu of fixed dam according to report and recommendation of Board of Engineers, dated November tenth, eighteen hundred and ninety-one, and found in House Executive Document numbered twenty-five, Fifty-second Congress, first session, fifty thousand dollars: *Provided*, That in addition to the said sum the balance on hand from former appropriations made for the fixed dam at that point is hereby made available for the movable dam herein provided for. Big Sandy River, Ky. Movable dam. *Proviso.* Balance available.

Improving Green River, Kentucky, above the mouth of the Big Barren River: For lock number five, according to report and recommendation of Major D. W. Lockwood, Corps of Engineers, United States Army, submitted August eleventh, eighteen hundred and ninety-one, fifty thousand dollars. Green River, Ky. Lock No. 5.

Improving Sandusky River, Ohio: Continuing improvement, five thousand dollars. Sandusky River, Ohio.

Improving Ohio River: Continuing improvement, three hundred and sixty thousand dollars, of which sum thirteen thousand dollars may be expended in completing the embankment on the south side of the Great Miami River near its junction with the Ohio River, to confine the waters of said Miami River in great floods to the general course of its channel at or near the Ohio, to the end that the formation of the bar in the Ohio now obstructing navigation may be arrested; and of said sum thirty thousand dollars, or so much thereof as may be necessary, may be used in improving the navigation of the river at Mound City, Illinois, and ten thousand dollars, or so much thereof as may be necessary, for dredging in Brooklyn Harbor, Illinois, and seven thousand dollars in completing the work at Shawneetown, Illinois. Ohio River. Mouth of Great Miami. Mound City, Ill. Brooklyn, Ill. Shawneetown, Ill.

Improving Ohio River by the construction of a movable dam at or below the mouth of Beaver River, Pennsylvania: Continuing improvement, one hundred thousand dollars; and the Secretary of War in his discretion may use so much thereof as may be necessary for the survey, location, and obtaining title to land for dam numbered two. Dam at mouth of Beaver River Pa.

Improving Saginaw River, Michigan: Continuing improvement, one hundred thousand dollars, of which five thousand dollars shall be expended on the West channel at Bay City, and forty thousand dollars, or such less sum as may be necessary, on the river above Bay City. Saginaw River, Mich.

Improving mouth of Black River, Michigan: Continuing improvement, ten thousand dollars. Black River, Mich.

Improving Clinton River, Michigan: Completing improvement, eight thousand five hundred and sixty-four dollars. Clinton River, Mich.

Improving Rouge River, Michigan: Completing improvement, eleven thousand six hundred and ninety dollars. Rouge River, Mich.

Improving Detroit River, Michigan, by removal of shoals from city of Detroit to Lake Erie: Continuing improvement, thirty thousand dollars. Detroit River, Mich.

Improving Thunder Bay River, Alpena, Michigan: Continuing improvement, ten thousand dollars. Thunder Bay River, Mich.

Improving Black River at Port Huron, Michigan: Continuing improvement up to Washington avenue, ten thousand dollars. Black River, Mich.

Improving the water communication across Keweenaw Point, Lake Superior, from Keweenaw Bay to Lake Superior, in the State of Michigan, for a navigable depth of sixteen feet with a minimum width of seventy feet at the bottom, and for repairs to existing revetments, fifty thousand dollars. Water way across Keweenaw Point, Lakes Superior and Michigan.

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Rouge River, Mich.
Turning basin.

For acquisition of land for site and beginning construction of turning basin in Rouge River, Michigan, according to plan of General O. M. Poe, Corps of Engineers, United States Army, submitted December twentieth, eighteen hundred and ninety, five thousand dollars.

Chippewa River, Wis.

Improving Chippewa River, including Yellow Banks, Wisconsin: Continuing improvement, five thousand dollars.

Fox River, Wis.

Improving Fox River, Wisconsin: Continuing improvement, seventy-five thousand dollars, of which five thousand dollars, or so much thereof as may be necessary, may be used for work in the harbor of Fond du Lac, Wisconsin, and approaches thereto.

Menominee River, Wis. and Mich.

Improving Menominee River, Wisconsin and Michigan: Completing improvement according to modified project, twenty thousand five hundred dollars.

Saint Croix River, Wis. and Minn.

Improving Saint Croix River, Wisconsin and Minnesota: Continuing improvement, eight thousand dollars.

Sturgeon Bay and Lake Michigan Ship Canal.

Proviso.
Title and jurisdiction.

For making free to commerce the Sturgeon Bay and Lake Michigan Ship Canal, connecting the water of Green Bay with Lake Michigan, in the State of Wisconsin, eighty-one thousand eight hundred and thirty-three dollars: *Provided*, That no money appropriated for this purpose shall be available until a valid title to all of said premises shall be vested in the United States, nor until the State of Wisconsin shall have ceded to the United States exclusive jurisdiction over the same, during the time the United States shall be or remain the owner thereof, for all purposes except the administration of the criminal laws of said State and the service of civil process on the lands and right of way so conveyed.

Red River of the North, Minn.

Improving Red River of the North, Minnesota: Continuing improvement, twenty-five thousand dollars.

Minnesota River, Minn.
Reappropriation.
Vol. 25, p. 419.

Improving Minnesota River, Minnesota: The sum appropriated by act of August eleventh, eighteen hundred and eighty-eight, is hereby made available for the improvement of the river, omitting the requirement for operations at Belle Plain, pursuant to recommendation of engineer officer, page twenty-two hundred and nine of the reports of eighteen hundred and ninety-one.

Wabash River, Ind. and Ill.

Improving Wabash River, Indiana and Illinois, above Vincennes: Continuing improvement, five thousand dollars.

Improving Wabash River, Indiana and Illinois, below Vincennes: Continuing improvement, sixty thousand dollars.

White River Ind.

Improving White River, Indiana: Continuing improvement, five thousand dollars.

Calumet River, Ill. and Ind.

Improving Calumet River, Illinois and Indiana: Continuing improvement, seventy-five thousand dollars, of which sixty thousand dollars is to be used below the forks of the river and fifteen thousand dollars above the forks to one-half mile east of Hammond.

Illinois River, Ill.

Improving Illinois River, Illinois: Continuing improvement, one hundred thousand dollars.

Illinois and Mississippi Canal.

Provisos.
Rights of way.

Basis.

Bridges, etc.

For the construction of the Illinois and Mississippi Canal: Continuing construction, five hundred thousand dollars, of which so much as may be necessary shall be used in acquiring the right of way for said canal: *Provided*, That in acquiring right of way the Secretary of War may make agreements for joint user where the canal crosses other lines of transportation if such agreements can be made upon reasonable terms: *Provided further*, That in acquiring the right of way by agreement or otherwise for the crossing of existing public highways over the parts of the canal constructed on land, the basis of agreement or condemnation shall be the construction and maintenance of bridges by the United States Government, as provided for in the detailed plans and estimates heretofore submitted to Congress, but this provision shall not apply to bridges constructed over public waters of the United States now occupying part of the line of the said canal, nor to bridges constructed after the completion of said canal or part thereof adjacent to the bridge sites.

Kaskaskia River, Ill.

Improving Kaskaskia River, Illinois, from mouth to Baldwin Bridge: Completing improvement, four thousand five hundred dollars.

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For care and maintenance of reservoirs at the headwaters of the Mississippi River, sixty thousand dollars, of which thirty thousand dollars may be expended for the construction of a navigable pass through the Sandy Lake dam.

Mississippi River.
Reservoirs at headwaters.

Improving the Mississippi River, from the mouth of the Ohio River to the landing on the west bank below the Washington avenue bridge, Minneapolis, Minnesota: Continuing improvement, one million one hundred and twenty-five thousand dollars: *Provided*, That on and after the passage of this act additional contracts may be entered into by the Secretary of War for such materials and work as may be necessary to carry on continuously the systematic improvement of the Mississippi River between the points mentioned, or said materials may be purchased and work may be done otherwise than by contract, to be paid for as appropriations may from time to time be made by law, not exceeding in the aggregate one million six hundred and twenty-five thousand dollars per annum for three years, commencing July first, eighteen hundred and ninety-three: *And provided further*, That of the amount herein appropriated five hundred and twenty-five thousand dollars shall be expended from the mouth of the Ohio River to the mouth of the Missouri River and six hundred thousand dollars from the mouth of the Missouri to Minneapolis; and the amounts for which additional contracts are authorized to be entered into shall be expended in like proportion. The Secretary of War is hereby directed to pay, out of the sum allotted to the river between the mouth of the Missouri River and Minneapolis, to M. J. Adams, five thousand dollars, in full of all claims and demands growing out of the test made by him of what is known as the Adams flume on the Upper Mississippi River, the said test having been authorized by Congress; and the Secretary of War shall expend fifty thousand dollars of said six hundred thousand dollars between the Chicago, Saint Paul, Minneapolis and Onaha Railway bridge at Saint Paul and the Washington avenue bridge, Minneapolis, and may, in his discretion, use a portion of said sum of six hundred thousand dollars, if necessary, to further protect the east bank of the river from erosion, and thus prevent the destruction of the embankment of the Sny Island levee, and a further portion, in his discretion, in the rectification of the river at Clarksville, Missouri, and in repair of harbors of refuge at Stockholm, Wisconsin, and Lake City, Minnesota, on Lake Pepin: *Provided*, That the Secretary of War be, and he is hereby, authorized to pay out of said appropriation the value of work actually done by the Hannibal Ferry Company, not exceeding the sum of two thousand one hundred and seven dollars and fifty cents, on the upper Mississippi River Government dyke, opposite Hannibal, Missouri, during the months of September, October, and November, eighteen hundred and ninety-one.

From mouth of Ohio to Minneapolis.
Provisos.
Additional contracts.
Distribution.
M. J. Adams, payment to.
Between St. Paul and Minneapolis.
Sny Island levee.
Clarksville, Mo.
Harbors of refuge.
Hannibal Ferry Company.
Payment to.

Improving Quincy Bay, Illinois: The balance on hand to credit of this improvement from the appropriation made in the river and harbor act of September nineteenth, eighteen hundred and ninety, is hereby authorized to be expended, or so much thereof as may be necessary, in constructing a retaining levee on Whipple Creek Bar to hold the material dredged from the bay, as recommended by the engineer in charge in the report for eighteen hundred and ninety-one, page twenty-one hundred and twenty-one.

Quincy Bay, Ill.
Balance to be used for levee, Whipple Creek Bar.
Vol. 20, p. 450.

Improving Mississippi River from Head of the Passes to the mouth of the Ohio River, including salaries, clerical, office, traveling, and miscellaneous expenses of the Mississippi River Commission: Continuing improvment, two million dollars, which sum shall be expended, under the direction of the Secretary of War, in accordance with the plans, specifications, and recommendations of the Mississippi River Commission, as approved by the Chief of Engineers, for the general improvement of the river, for the building of levees, and for surveys, including the survey from the Head of the Passes to the headwaters of the river, in such manner as in their opinion shall best improve navigation and promote the interests of commerce at all stages of the river: *Provided*, That on

Mississippi River Commission.
Head of the Passes to mouth of Ohio.
Salaries, etc.
Provisos.

Additional contracts. Limit.

and after passage of this act additional contracts may be entered into by the Secretary of War for such materials and work as may necessary to carry on continuously the plans of the Mississippi River Commission as aforesaid, or said materials may be purchased and work may be done otherwise than by contract, to be paid for as appropriations may from time to time be made by law, not exceeding in the aggregate two million six hundred and sixty-five thousand dollars per annum for three years, commencing July first, eighteen hundred and ninety-three.

For work in accordance with the plans and specifications of the Mississippi River Commission.

Greenville, Miss.

At the harbor of Greenville, Mississippi: Continuing improvement, one hundred thousand dollars.

Vicksburg, Miss.

At the harbor at Vicksburg, Mississippi: Continuing improvement, eighty thousand dollars.

New Orleans, La.

At the harbor of New Orleans, Louisiana: Continuing improvement, eighty thousand dollars.

Natchez, Miss, and Vidalia, La.

At the harbor of Natchez and Vidalia, Mississippi and Louisiana, eighty thousand dollars.

Memphis, Tenn.

At the harbor of Memphis, Tennessee, twenty-five thousand dollars.

New Madrid, Mo.

At the harbor of New Madrid, Missouri, twenty-five thousand dollars.

Atchafalaya and Red rivers, La.

At the head of the Atchafalaya and the mouth of Red River, Louisiana, for the rectification thereof: Continuing improvement, eighty thousand dollars.

Great Lakes. Ship channel, Chicago, Duluth and Buffalo. *Proviso.* Contracts.

For ship channel twenty and twenty-one feet in depth, and a minimum width of three hundred feet, in the shallows of the connecting waters of the Great Lakes between Chicago, Duluth, and Buffalo, three hundred and seventy-five thousand dollars: *Provided*, That contracts may be entered into by the Secretary of War for such materials and work as may be necessary to carry out the plans proposed by General O. M. Poe, Corps of Engineers, United States Army, date January twentieth, eighteen hundred and ninety-one, and printed as House Executive Document, numbered Two hundred and seven, second session Fifty-first Congress, for such ship channel, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate two million nine hundred and sixty-five thousand dollars, exclusive of the amount herein appropriated.

Limit.

Gasconade River, Mo.

Improving Gasconade River, Missouri: Continuing improvement, four thousand dollars.

Osage River, Mo.

Improving Osage River, Missouri: Continuing improvement, fifty thousand dollars.

Missouri River. Between Great Falls, Mont., and Sioux City.

Improving Missouri River between the foot of the Great Falls of the said river, in Montana, and Sioux City: Continuing improvement one hundred and fifty thousand dollars, a portion of which may be used, in the discretion of the Secretary of War, in the rectification of said river and bank protection at the cities of Pierre and Yankton, South Dakota.

Missouri River Commission. Salaries, etc. Improvement.

Improving the Missouri River from its mouth to Sioux City, Iowa, including salaries, clerical, office, traveling and miscellaneous expenses of the Missouri River Commission, surveys, permanent bench marks, and gauges: Continuing improvement, six hundred thousand dollars, to be expended under the direction of the Secretary of War in the systematic improvement of the river according to the plans and specifications of the Missouri River Commission, as approved by the Chief of Engineers: *Provided*, That in the discretion of said Commission a portion of such sum may be expended in the protection of harbors and localities on the river within said limits: *And provided also*, That on and after the passage of this act additional contracts may be entered into by the Secretary of War for such materials and work as may be necessary to carry on continuously the plans of the Missouri River Commission for the improvement of said river, or said materials may be purchased and work may be done otherwise than by contract, to be paid for as appropriations may from time to time be made by law, not exceeding in the aggregate seven hundred and fifty thousand

Proviso. Harbors. Additional contracts. Limit.

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dollars per annum for three years, commencing July first, eighteen hundred and ninety-three.

Examination of Missouri River from Three Forks to Canyon Ferry, Montana, with a view of determining at what points, if any, use might be made of water power for manufacturing or other purposes, without unreasonably impairing the navigability of that portion of said river, two thousand five hundred dollars. Missouri River. Examination for water power

Improving Colorado River by construction of a levee on the Gila River near its junction with the Colorado River at Yuma, Arizona, so as to confine the waters to the channel of said rivers, ten thousand dollars. Colorado River, Ariz.

Improving Sacramento and Feather rivers, California, according to plan of the Board of Engineers, appointed pursuant to the provision of the act of September nineteenth, eighteen hundred and ninety, submitted February third, eighteen hundred and ninety-one, and printed as House Executive Document, number Two hundred and forty-six, Fifty-first Congress, second session, including treatment of the Yuba River near and above Marysville, one hundred and fifty thousand dollars. Sacramento and Feather rivers, Cal. Vol. 26, p. 456.

Improving San Joaquin River, California, including making the cut-off at Twenty-one Mile Slough and the double cut-off between Stockton Channel and Devil's Elbow, as proposed by Major W. H. Heuer: Continuing improvement, sixty-five thousand dollars: *Provided*, That no money shall be expended for making the cut-offs until the right of way on the line of the cut-offs shall have been conveyed to the United States free of expense. San Joaquin River, Cal. *Proviso.* Right of way.

Improving Petaluma Creek, California: Continuing improvement, ten thousand dollars. Petaluma Creek, Cal.

Improving Mokelumne River, California: Continuing improvement, two thousand five hundred dollars: *Provided*, That no part of said sum shall be used until the drainage canal cut by private parties near New Hope Landing shall have been closed. Mokelumne River, Cal. *Proviso.* Drainage canal.

Improving canal at the Cascades of the Columbia River, Oregon: Continuing improvement, three hundred and twenty-six thousand two hundred and fifty dollars: *Provided*, That contracts may be entered into by the Secretary of War for such materials and work as may be necessary to complete the present project of improvement of the Columbia River at that point, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate one million four hundred and nineteen thousand two hundred and fifty dollars, exclusive of the amount herein and heretofore appropriated. Cascades of Columbia River *Proviso.* Contracts. Limit.

The President is hereby authorized to appoint a board of engineers to consist of seven members, of whom three shall be from civil life, whose duty it shall be to thoroughly examine the obstructions to navigation in the Columbia River, in that portion from the navigable waters thereof below Three Mile Rapids to the navigable waters above the Celilo Falls, and report as soon as they conveniently can to the Secretary of War such plan for overcoming or removing said obstructions as in their opinion is most feasible and best adapted to the necessities of commerce, together with a statement as to the usefulness of such improvement to navigation, its relation and value to commerce and the most desirable location therefor, the cost of construction and of the right of way, including the necessary land therefor being considered. They shall also report the details of such plans, with estimates of its cost. The sum of twenty thousand dollars, or so much thereof as may be necessary, is hereby appropriated to defray the cost of such examination and survey and the expenses of said board. Board of engineers to report on removal of obstructions to navigation, Columbia River.

Improving Upper Columbia River, including Snake River, as far up as Asotin, Oregon and Washington: Continuing improvement, fifteen thousand dollars. Upper Columbia River, Oreg. and Wash.

Improving mouth of Columbia River, Oregon: Continuing improvement, three hundred and fifty thousand dollars. Columbia River, Oreg.

Improving Willamette River at and above Portland, Oregon: Continuing improvement, thirty thousand dollars, of which three thousand dollars shall be used in removing obstructions in Yamhill River up to McMinnville. Willamette River, Oreg.

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Lower Willamette and Columbia rivers, Portland, Oreg.

Improving Lower Willamette and Columbia rivers, in front of and below Portland, Oregon: Continuing improvement, one hundred and fifty thousand dollars, to be applied to obtaining a twenty-five foot channel.

Coquille River, Oreg.

Improving Coquille River, Oregon: Continuing improvement, twenty-five thousand dollars.

Siuslaw River, Oreg.

Improving the mouth of the Siuslaw River, Oregon: Continuing improvement, twenty thousand dollars.

Upper Coquille River, Oreg.

Improving Upper Coquille River, between Coquille City and Myrtle Point, Oregon: Five thousand dollars, to be used in deepening channel to four feet at mean low water.

Snake River, Idaho.

Improving Upper Snake River, Idaho, between Huntington Bridge and Seven Devils mining district, twenty thousand dollars.

Cowlitz River, Wash.

Improving Cowlitz River, Washington: Continuing improvement, three thousand dollars.

Puget Sound, etc., Wash.

Improving Puget Sound and its tributary waters, Washington: Continuing improvement, fifteen thousand dollars.

Swinomish Slough, Wash.

Improving Swinomish Slough, Washington: For a channel four feet in depth at the mean of the lower low waters, twenty-five thousand dollars.

Nasel River, Wash.

Improving Nasel River, Washington: Completing improvement, one thousand five hundred dollars.

Columbia River, Wash.

Improving Columbia River, Washington, between the mouth of the Willamette River and the city of Vancouver: Completing improvement, in accordance with the plan recommended by Major Thomas H. Handbury, and printed in House Executive Document numbered Thirty-six, Fifty-second Congress, first session, thirty-three thousand dollars.

Willapa River, Wash.

Improving Willapa River and Harbor, Washington, eighteen thousand dollars, of which eight thousand dollars may be used for closing Mailboat Slough.

Rejection of bids not advantageous.

SEC. 2. That in cases where authority has been granted to the Secretary of War in this act to make contracts for the completion of certain works of river and harbor improvement, he is hereby authorized to reject any bids not in his opinion advantageous to the Government, and to issue new proposals.

Vol. 26, p. 54, amended.

SEC. 3. That section seven of the river and harbor act of September nineteenth, eighteen hundred and ninety, be amended and re-enacted so as to read as follows:

Obstructions by wharves, etc.

"SEC. 7. That it shall not be lawful to build any wharf, pier, dolphin, boom, dam, wier, breakwater, bulkhead, jetty, or structure of any kind outside established harbor lines, or in any navigable waters of the United States where no harbor lines are or may be established, without the permission of the Secretary of War, in any port, roadstead, haven, harbor, navigable river, or other waters of the United States, in such manner as shall obstruct or impair navigation, commerce, or anchorage of said waters; and it shall not be lawful hereafter to commence the construction of any bridge, bridge draw, bridge piers and abutments, causeway, or other works over or in any port, road, roadstead, haven, harbor, navigable river or navigable waters of the United States, under any act of the legislative assembly of any State, until the location and plan of such bridge or other works have been submitted to and approved by the Secretary of War, or to excavate or fill, or in any manner to alter or modify the course, location, condition or capacity of any port, roadstead, haven, harbor, harbor of refuge, or inclosure within the limits of any breakwater, or of the channel of any navigable water of the United States, unless approved and authorized by the Secretary of War:

Construction of bridges, etc., under State law

Secretary of War to approve plans, etc.

Altering, etc., ports., etc., forbidden.

Proviso.

Existing lawful bridges, etc., excepted.

Provided, That this section shall not apply to any bridge, bridge draw, bridge piers, and abutments the construction of which has been heretofore duly authorized by law, or be so construed as to authorize the construction of any bridge, draw bridge, bridge piers and abutments or other works under an act of the legislature of any State, over or in any stream, port, roadstead, haven or harbor or other navigable water not wholly within the limits of such State.

No authority for bridges under State law over waters not wholly in State.

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SEC. 4. That any permission granted by the Secretary of War under the provisions of an act of Congress entitled "An act to authorize the construction of bridges across the Ohio River, and to prescribe the dimensions of the same," approved December seventeenth, eighteen hundred and seventy-two, as amended by an act supplementary thereto, approved February fourteenth, eighteen hundred and eighty-three, for the construction of a bridge over said river, shall be null and void if said construction be not actually commenced within one year and completed within three years from the date of said permission.

Bridges across Ohio River. Vol. 17, p. 398.

Vol. 22, p. 414.

Limit for construction.

SEC. 5. That no money appropriated for the improvement of rivers and harbors in this act or hereafter, shall be expended for dredging inside of harbor lines duly established.

Dredging within harbor lines.

SEC. 6. That the Secretary of War is hereby directed to cause preliminary examinations to be made at the following localities, to wit:

Surveys.

ARKANSAS.

Arkansas.

Saline River.
Little River.
Fourche Le Fevre and Current River.
Ouachita River, above Camden.

CALIFORNIA.

California.

Old River Branch of San Joaquin River.
San Joaquin River from Hill's Ferry to Firebaugh's Ferry, including closing of sloughs on the river above Stockton.
Navigable sloughs, in the bay of San Francisco.
Merced River.
Mouth of Navarro River.
Tuolumne River.
Harbor of Crescent City.
Stanislaus River.
Entrance to harbor of San Francisco, known as Golden Gate.
Alviso Slough.

CONNECTICUT.

Connecticut.

Norwalk Harbor.
Westport Harbor.
Stonington Harbor, and the entrance thereto.

DELAWARE.

Delaware.

Nanticoke River.
Mouth of Saint Jones' River.
For inland water way connecting the Mispillion and Broadkiln rivers so as to reopen the navigation of Cedar, Slaughter, and Primehook creeks.

FLORIDA.

Florida.

Harbor at Cape Canaveral.
The bar at the junction of Choctawhatchee Bay and Santa Rosa Sound.
The bar at the mouth of Alaqua Bayou, at its entrance into Choctawhatchee Bay.

GEORGIA.

Georgia.

Savannah River between Spirit Island and the point where the Charleston and Savannah Railway crosses said river.

IDAHO.

Idaho.

Kootenai River, from Fry, Idaho, to international boundary line.
Spokane River, from Post Falls to Lake Cœur d'Alene.

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Iowa.

IOWA.

Mississippi River at and near Bellevue, Iowa, with a view to so repairing and fixing dam that ferry channel will be restored.

Mississippi River, Iowa side from mouth of Iowa River to Burlington, to determine the best method of removing the bars and deepening the channel.

Indiana.

INDIANA.

Harbor at Evansville.

Wolf River Harbor, on Lake Michigan; and the engineer will report whether Wolf River and lake are navigable water ways of the United States or whether covered in whole or in part by claims of private ownership.

Illinois.

ILLINOIS.

Ohio River at or near Elizabethtown, Illinois, for the purpose of determining the most practicable method of improving the harbor at that place.

Hamburg Bay, on the Mississippi River, in Calhoun County.

Little Wabash and Embarras rivers.

Outer harbor at mouth of Calumet River.

Harbor at Moline.

Kansas.

KANSAS.

Kansas River.

Kentucky.

KENTUCKY.

Ohio River between the cities of Ludlow and Covington, in Kentucky, and Cincinnati, Ohio, from the Chesapeake and Ohio Railway bridge to the Cincinnati Southern Railway bridge to prevent washing and damage to banks on Kentucky shore.

Ohio River between Livingston Point and the head of Tennessee Island with the view of protecting the harbor and marine ways at Paducah, Kentucky.

Licking River, with a view to providing slack-water navigation.

Big Sandy River from its junction with the Ohio River to the crossing of the Big Sandy by the Chesapeake and Ohio Railroad bridge, with a view of ascertaining if there be a bar in the Ohio River at the mouth of said Big Sandy obstructing navigation, and if there be whether confining the waters of the Big Sandy to the general course of its channel between said points the said bar will be removed.

Louisiana.

LOUISIANA.

Harbor of refuge on Lake Pontchartrain, most suitable point at or near entrance into the Old and New basins.

Bayous Black and Terrebonne, with a view of connecting them between Southdown Plantation and Houma, Louisiana, and opening a shorter and safer inland water route from the Mississippi Valley via Berwicks Bay to Texas and Mexico.

Maine.

MAINE.

Rockland Harbor.
Tennants Harbor.
Vinal Haven.
Carver Harbor.
Owl Head Harbor.
French's Beach Harbor.
Lincolnville Harbor.
South Fork of Bagaduce River.
George's River.

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Portland Harbor, with a view to extending the channel along the front of the wharves on the south side of the harbor, so as to give a depth of eight feet at mean low water as far south as the plush mill wharf.

Channel near Hardy's Point below Pembroke.

MASSACHUSETTS.

Massachusetts

Vincent Cove, Gloucester Harbor.

Gloucester, from Five Pound Island to head of river.

Neponsit River.

New Bedford Harbor.

Woods Holl.

East Boston channel, from the southeasterly line of the location of the Boston, Revere Beach and Lynn Railroad to the channel at Jeffries Point, so called, and Chelsea River, from Grand Junction railroad bridge to the Boston and Maine, eastern division, railroad bridge.

Tarpaulin Cove, Naushon Island, for a breakwater.

Saugus River.

MISSISSIPPI.

Mississippi.

Pearl River near Jackson, Mississippi, to determine whether it would be advantageous to divert the river from its present channel so that it would flow through what is known as "Tanyard Branch," and if so whether it is feasible and what it would cost to so divert it.

Mississippi Sound, outside of the range of islands off the Mississippi coast, with a view of making an entrance for vessels.

Biloxi Bay, known as Back Bay, north of the town of Biloxi and up to town of Handsboro, with a view of removing bars.

Pearl River, Edinburg to Lake Burnside.

Bar at the mouth of Wolf River.

Bar at the mouth of Jordan River.

Homochitto River, from its mouth to the Louisville, New Orleans and Texas Railroad bridge.

Channel at mouth of Old Fort Bayou.

Cassidys Bayou, Cold Water River.

MARYLAND.

Maryland.

South Branch of Patapsco River, at Baltimore, from Craighill Channel to Light Street bridge.

Middle Branch of Patapsco River, from Light Street bridge to foot of Eutaw street.

Pocomoke River, with a view of uniting the waters of said river with the waters of Synepuxent Bay, at a point above Snow Hill.

Black Walnut Harbor, at the mouth of Great Choptank River.

Mouth of Parish Creek.

Wicomico River, western shore of the State.

MICHIGAN.

Michigan.

Pine River, at Saint Clair City.

Belle River, Marine City, from its mouth to Broadway Street bridge.

Hammond Bay, Lake Huron, at the mouth of Ocqueoc River.

Sebewaing River, Saginaw Bay.

NEW JERSEY.

New Jersey

Whale Creek.

Cooper Creek.

Dennis Creek.

Barnegat Inlet, entrance and harbor.

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New York.

NEW YORK.

Harbor of refuge in Mexico Bay on Lake Ontario.
Channel connecting Freeport with Great South Bay.
Berrian's Creek, Long Island.
Seaford Creek, Long Island.
Southold Harbor, Long Island.
Fort Pond Bay at the east end of Long Island, including an estimate of the cost of an adequate breakwater.
For channel west of Robbins Reef Light-House to connect the mouth of Arthur Kill with New York Harbor.
Dunkirk Harbor, with a view of securing sixteen feet of water.
Allegheny River, from Olean, New York, to Warren, Pennsylvania.

North Carolina.

NORTH CAROLINA.

For breakwater to protect town of Beaufort.
Potohunk River.
Durham's Estuary from mouth to village of Edwards Mills.

Ohio.

OHIO.

Ohio River between Ironton, Ohio, and three miles along and up the Ohio east of the mouth of Guyan River, West Virginia, for the purpose of ascertaining what is necessary to clear said river between said points of obstructions and to deepen the channel thereof where necessary, with all such other improvements as may be found expedient for the storing and harboring of steamboats, coal barges, and for the landing and shipping of coal and other freights on said river between said point.
Little Miami River, with the view of affording an ice harbor.
Raccoon River from its junction with the Ohio River for fifty miles of said Raccoon River.

Oregon.

OREGON.

Chetco River.
Inner navigation of Alsea River.
Nestucca River, as far as Woods.
Rogue River, from Grant Pass to the mouth
Navigable tide-water channels of Coos River, with a view to remove snags, logs, and other obstructions.
Yamhill River, from mouth to McMinnville, for slackwater navigation by lock and dam at Lafayette.
Willamette River, above Oregon City.
Harbor at Yaquina Bay, with a view to obtaining twenty-five feet of water at mean low water upon the bar at the entrance.

Pennsylvania.

PENNSYLVANIA.

For lock and dam on Allegheny River, at or near Tarentum.
For lock and dam at the most practicable point for navigation on Allegheny River, between the dam at Tarentum and Herr Island Dam.
For the location of the necessary number of movable locks and dams on the Ohio River between Davis Island Dam and the dam at or near the mouth of the Beaver River, in Pennsylvania.

Rhode Island.

RHODE ISLAND.

Apponaug Harbor, Cowessett Bay.
Wickford Harbor, Narragansett Bay.
Breachway into Salt Pond, Block Island.
Greenwich Harbor, Greenwich Bay.
Pawtuxet Harbor, Providence River. Inner Harbor at Point Judith Breakwater.

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SOUTH CAROLINA.

South Carolina.

Lynch River.

SOUTH DAKOTA.

South Dakota.

James River.

TENNESSEE.

Tennessee.

Sequatchie River.

Duck River.

Hiawassee River in Tennessee from its confluence with the Tennessee River to the mouth of the Ocoee River.

Wolf River.

Harbor at Memphis, including removal of bar forming opposite the upper part of the city, and bank protection along the city front.

Emory River, from its mouth to Harriman.

TEXAS.

Texas.

Channel through Sabine Lake from Sabine Pass to mouths of Sabine and Neches Rivers.

Sabine River, from Sudduth's Bluff to Logansport, Louisiana.

Brazos River, from its mouth to the town of Richmond.

From the mouth of Neches River to Shooks Bluff.

Sulphur River from its mouth to Sulphur Station.

VERMONT.

Vermont.

Harbor at Adams Landing, so called, on Grand Isle, and North Hero Harbor, on Lake Champlain.

VIRGINIA.

Virginia.

Milford Haven, bar at mouth.

Morattico Creek, obstruction at mouth.

Little Wicomico River, obstruction at mouth.

Harbor at Petersburg and Appomattox River, for diversion of waters to Old North Channel above city.

WASHINGTON.

Washington.

Snohomish River from mouth to Lowell.

Lewis River from its mouth to Speliah Creek.

Nooksack River, with a view of removing obstructions, straightening channel to prevent jams and the filling of Bellingham Bay with deposits of earth.

Everett Harbor, including mouth of Snohomish River.

Upper Columbia River, Washington, from the international boundary to Rock Island Rapids.

WISCONSIN.

Wisconsin.

Lake Pepin, whether additional harbors of refuge are necessary, and if necessary, where the same should be located.

Green Bay, from light-house to first bridge on Fox River.

Harbor at Stockbridge on Lake Winnebago.

Harbor at Calumet on Lake Winnebago.

Fox River, on the necessity and advisability of building a protection wall on the canal at Kaukauna.

Allouez Bay and Nemadji River, at Superior.

Preliminary examinations.

SEC. 7. That the preliminary examinations ordered in this act shall be made by the local engineer in charge of the district, or an engineer detailed for the purpose; and such local or detailed en-

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Report. Details. gineer and the division engineer of the locality shall report to the Chief of Engineers, first, whether, in their opinion, the harbor or river under examination is worthy of improvement by the General Government, and shall state in such report fully and particularly the facts and reasons on which they base such opinions, including the present and prospective demands of commerce; and, second, if worthy of improvement by the General Government, what it will cost to survey the same, with the view of submitting plan and estimate for its improvement; and the Chief of Engineers shall submit to the Secretary of War the reports of the local and division engineers, with his views thereon and his opinion of the public necessity or convenience to be subserved by the proposed improvement; and all such reports of preliminary examinations, with such recommendations as he may see proper to make, shall be transmitted by the Secretary of War to the House of Representatives, and are hereby ordered to be printed when so made.

Reports to be sent to House of Representatives and printed.

Appropriation for examinations, etc.

SEC. 8. For preliminary examinations, contingencies, expenses connected with inspection of bridges, the service of notice required in such cases, the examination of bridge sites and reports thereon, and for incidental repairs for which there is no special appropriation for rivers and harbors, one hundred and twenty-five thousand dollars: *Provided*, That no preliminary examination, survey, project, or estimate for new works other than those designated in this act shall be made: *And provided further*, That after the regular or formal report on any examination, survey, project, or work under way or proposed is submitted, no supplemental or additional report or estimate, for the same fiscal year, shall be made unless ordered by a resolution of Congress. The Government shall not be deemed to have entered upon any project for the improvement of any water way or harbor mentioned in this act until funds for the commencement of the proposed work shall have been actually appropriated by law.

Provisos. No survey, etc., unless provided for. No supplemental reports, etc., to be made. No project authorized until appropriation made.

Approved, July 13, 1892.

July 13, 1892.

CHAP. 160.—An act authorizing the Aransas Harbor Terminal Railway Company to construct a bridge across the Corpus Christi Channel, known as the Morris and Cummings Ship Channel, in Aransas County, Texas.

Aransas Harbor and Terminal Railway Company may bridge Corpus Christi Channel, Tex. Railway bridge.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Aransas Harbor Terminal Railway Company, a corporation chartered under the laws of the State of Texas, is hereby authorized and empowered to erect, construct, maintain, and operate a bridge over and across the Corpus Christi Channel, known as the Morris and Cummings Ship Channel, in Aransas County, Texas. Said bridge shall be constructed to provide for the passage of railway trains on and over a double or single track as said Aransas Harbor Terminal Railway Company may elect.

Draw.

SEC. 2. That said bridge shall be constructed with a draw or turn of sufficient capacity to afford free passage to such vessels and boats as navigate said channel: *Provided*, That said bridge shall be opened promptly upon reasonable signal for the passage of boats and other water craft, except when trains are passing over the draw or turn; but in no case shall unnecessary delay occur in opening the draw or turn after the passage of trains or at any other time; and the said Aransas Harbor Terminal Railway Company shall maintain at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the United States Light-House Board shall prescribe. And no bridge shall be erected and maintained under the authority of this act which shall at any time substantially or materially obstruct the free navigation of said channel; and if any bridge erected under such authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of such bridge to be made as will effectually obviate such ob-

Provisos. Opening draw. Lights, etc. Unobstructed navigation.

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struction, and all such alterations shall be made and all such obstructions be removed at the expense of the owner of said bridge. And in case of any obstruction, or alleged obstruction, to the navigation of said channel, caused, or alleged to be caused, by said bridge, the case may be brought in the circuit court of the United States in which any portion of said obstruction or bridge may be located: *Provided further*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of navigation of rivers, or to exempt this bridge from the operations of the same. That all railroad companies desiring the use of any bridge constructed under this act shall have and be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same and over the approaches thereto upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any one of them desiring such use, shall fail to agree upon the sum or sums to be paid, and upon rules and conditions to which each shall conform in using said bridge, all matters at issue betwen them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties.

Litigation.

Existing laws not affected.

Use by other companies.

Terms.

SEC. 3. That any bridge authorized to be constructed under this act shall be located and built under and subject to such regulations for the security of said channel as the Secretary of War shall prescribe; and to secure that object, the said corporation shall, at least two months previous to the commencement of the construction of said bridge, submit to the Secretary of War, for his examination and approval, a design and drawing of the bridge and a map of the location, giving such information as may be necessary to enable the Secretary of War to judge of the proper location of said bridge, and shall furnish such information as may be required for a full and satisfactory understanding of the subject; and until such plan and location of the bridge are approved by the Secretary of War, the bridge shall not be built: and should any change be made in the plan of said bridge during the progress of construction or after completion such change shall be subject to the approval of the Secretary of War.

Secretary of War to approve plans, etc.

Changes.

SEC. 4. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in said structure, or its entire removal at the expense of the owners thereof, whenever Congress shall decide that the public interest requires it, is also expressly reserved.

Amendment, etc.

SEC. 5. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the passage of this act.

Commencement and completion.

Approved, July 13, 1892.

CHAP. 170.—An act to authorize the Lake Charles Road and Bridge Company, of Lake Charles, Louisiana, to construct and maintain bridges across English Bayou and Calcasieu River.

July 14, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Lake Charles Road and Bridge Company, a corporation created and existing under and by virtue of the laws of the State of Louisiana, or its assigns, to erect, construct, and maintain a bridge over the English Bayou and a bridge over Calcasieu River, in the State of Louisiana, at such points upon said bayou and river in township nine south and range eight west as may be found advantageous. Said bridges shall be constructed to provide for the passage of wagons and vehicles of all kinds, for the transit of animals, foot passengers, and of all kinds of commerce, travel, or communication, and said corporation may charge and receive such reasonable tolls therefor as may be approved from time to time by the Secretary of War.

Lake Charles Road and Bridge Company may bridge English Bayou and Calcasieu River, La.

Wagon, foot, etc., bridge.

Tolls.

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Draws.

SEC. 2. That each of said bridges shall be constructed as draw-bridges, with an opening over the center of the channel of such width as the Secretary of War shall determine, and which shall not be less than thirty feet in the clear across English Bayou and not less than fifty feet in the clear across Calcasieu River: *Provided also*, That said draws shall be opened promptly upon reasonable signal for the passage of boats, vessel, or other water craft, and in no case shall unnecessary delay occur; and said company or corporation shall maintain, at its own expense, from sunset to sunrise, such lights or other signals on said bridges as the Light House Board shall prescribe, and such sheer booms or other structures as may be necessary to safely guide vessels, boats, rafts, or other water craft safely through said draw openings as shall be designated and required by the Secretary of War.

Proviso. Opening draws.

Lights, etc.

Secretary of War to approve plans, etc.

SEC. 3. That said bridges shall be built and located under and subject to such regulations for the security of navigation of said bayou and river as the Secretary of War shall prescribe, and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval a design and drawings of the bridges and a map of the location, given for the space of one mile above and one mile below the proposed location the topography of the banks of the bayou and river, the shore lines at high and low water, the direction and strength of the current at all stages, and the soundings, accurately showing the bed of the streams, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plans and locations are approved by the Secretary of War the bridges shall not be built; and should any changes be made in the plans of said bridges during the progress of construction such change shall be submitted to the approval of the Secretary of War.

Amendment, etc.

SEC. 4. That the right to alter, amend, or repeal this act, or to require any changes in such structures, or their entire removal at the expense of the owners thereof, whenever the Secretary of War shall decide that the public interest requires it, and the right to prescribe such rules and regulations in regard to toll and otherwise as may be deemed reasonable, are expressly reserved.

Commencement and completion.

SEC. 5. That this act shall be null and void if actual construction of the bridges herein authorized be not commenced within two years and completed within three years from the date hereof.

Approved, July 14, 1892.

July 14, 1892.

CHAP. 171.—An act making appropriations to provide for the expenses of the government of the District of Columbia for the fiscal year ending June thirtieth, eighteen hundred and ninety-three, and for other purposes.

District of Columbia appropriations.

Half from District revenues.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the half of the following sums named, respectively, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, and the other half out of the revenues of the District of Columbia, for the purposes following, being for the expenses of the government of the District of Columbia for the fiscal year ending June thirtieth, eighteen hundred and ninety-three, namely:

GENERAL EXPENSES.

Salaries, etc.

FOR SALARIES AND CONTINGENT EXPENSES.

Executive office. Commissioners, secretary, etc.

FOR EXECUTIVE OFFICE: For * * * one Engineer Commissioner, one thousand seven hundred and sixty-eight dollars (to make salary five thousand dollars);

* * * * * * *

CARE OF BRIDGES: For ordinary care of bridges, including keepers, oil, lamps, and matches, five thousand dollars; for construction and repairs of bridges, fourteen thousand dollars; in all, nineteen thousand dollars. That the Washington and Georgetown Railroad Company is hereby required to repair the bridge across Rock Creek at M street northwest at a cost not exceeding ten thousand dollars, said repairs to be made under the direction of the Engineer Commissioner of the District of Columbia and in accordance with plans and specifications to be prepared by him.

Bridges.

Washington and Georgetown Railroad Company to repair M street bridge.

WASHINGTON AQUEDUCT.

Aqueduct.

For engineering, maintenance, and general repairs, twenty thousand dollars.

Engineering, etc.

* * * * * * *

Approved, July 14, 1892.

CHAP. 172.—An act making appropriations for the support of the Military Academy for the fiscal year ending June thirtieth, eighteen hundred and ninety-three.

July 14, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, for the support of the Military Academy for the fiscal year ending June thirtieth, eighteen hundred and ninety-three:

Military Academy appropriations.

For pay of one Superintendent of the United States Military Academy (colonel), in addition to pay as lieutenant-colonel of engineers, five hundred dollars.

Pay of Superintendent, professors, etc.

* * * * * * *

For pay of one instructor of practical military engineering (major), in addition to pay as first lieutenant, nine hundred dollars.

* * * * * * *

For department of practical military engineering: For * * * extra-duty pay of engineer soldiers, at fifty cents per day each, when performing special skilled mechanical labor in the department of practical military engineering.

Department of practical military engineering.

* * * * * * *

Approved, July 14, 1892.

CHAP. 195.—An act making appropriations for the support of the Army for the fiscal year ending June thirtieth, eighteen hundred and ninety-three, and for other purposes.

July 16, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and they are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, for the support of the Army for the year ending June thirtieth, eighteen hundred and ninety-three.

Army appropriations.

* * * * * * *

MISCELLANEOUS.

Miscellaneous.

* * * * * * *

For additional pay to officer in charge of public buildings and grounds, in Washington, District of Columbia, one thousand dollars.

Public buildings, etc., D. C.

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Eginneer Department.

ENGINEER DEPARTMENT.

Incidental expenses.

Engineer Depot at Willets Point, New York: Incidental expenses of the depot, including fuel, lights, chemicals, stationery, hardware, extra-duty pay to soldiers necessarily employed for periods not less than ten days as artificers on work in addition to and not strictly in line of their military duties, such as carpenters, blacksmiths, draftsmen, printers, lithographers, photographers, engine drivers, teamsters, wheelwrights, masons, machinists, painters, overseers, laborers, repairs of and for materials to repair public buildings, machinery, and unforeseen expenses, four thousand dollars.

Material.

For purchase of materials for the instruction of engineer troops at Willets Point in their special duties of sappers and miners, for land and submarine mines, and pontooneers, torpedo drill, and signaling, thirty-five hundred dollars.

Instruments.

For purchase and repair of instruments to be issued to officers of the corps of engineers and to officers detailed and on duty as acting engineer officers for use on public works and surveys, two thousand dollars.

Books.

Library of the Engineer School of Application: Purchase and binding of professional works of recent date treating of military and civil engineering and kindred scientific subjects, five hundred dollars.

Pontoon material.

The purchase of pontoon material required to complete one division of reserve and one division of advance-guard equipage, five thousand dollars.

In all, fifteen thousand dollars.

* * * * * * *

Approved, July 16, 1892.

July 16, 1892.

CHAP. 196.—An act making appropriations for the legislative, executive, and judicial expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and ninety-three, and for other purposes.

Legislative, executive, and judicial expenses, appropriations.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, in full compensation for the service of the fiscal year ending June thirtieth, eighteen hundred and ninety-three, for the objects hereinafter expressed, namely:

* * * * * * *

War Department.

WAR DEPARTMENT.

* * * * * * *

Engineer office.

IN THE OFFICE OF THE CHIEF OF ENGINEERS: Chief clerk, at two thousand dollars; four clerks of class four; two clerks of class three; three clerks of class two; three clerks of class one; one clerk, at one thousand dollars; one assistant messenger; and two laborers; in all, twenty-three thousand two hundred and forty dollars.

Draftsmen, etc.

And the services of skilled draftsmen, civil engineers, and such other services as the Secretary of War may deem necessary, may be employed only in the office of the Chief of Engineers to carry into effect the various appropriations for rivers and harbors, fortifications, and surveys to be paid from such appropriations: *Provided*, That the expenditures on this account for the fiscal year ending June thirtieth, eighteen hundred and ninety-three, shall not exceed sixty thousand dollars; and that the Secretary of War shall each year, in the annual estimates, report to Congress the number of persons so employed and the amount paid to each.

Proviso.

Limit.

Report.

* * * * * * *

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PUBLIC BUILDINGS AND GROUNDS.

Public buildings and grounds.

OFFICE OF PUBLIC BUILDINGS AND GROUNDS: For one clerk. one thou and six hundred dollars; one messenger; one public gardener, one thousand eight hundred dollars; in all, four thousand two hundred and forty dollars.

Clerk, messenger, gardener.

For overseers, draftsmen. foremen, mechanics, gardeners, and laborers employed in the public grounds, thirty thousand dollars.

Overseers, etc

For day watchman in Franklin Square, six hundred and sixty dollars.

Watchmen.

For day watchman in La Fayette Square, six hundred and sixty dollars.

For two day watchmen in Smithsonian Grounds, at six hundred and sixty dollars each, one thousand three hundred and twenty dollars.

For two night watchmen in Smithsonian Grounds, at seven hundred and twenty dollars each, one thousand four hundred and forty dollars.

For one day watchman at Judiciary Square and one at Lincoln Square and adjacent reservations, at six hundred and sixty dollars each, one thousand three hundred and twenty dollars.

For one night watchman in Judiciary Square, seven hundred and twenty dollars.

For one day watchman at Iowa Circle: one at Thomas Circle and neighboring reservations; one at Rawlins Square and Washington Circle; one at Dupont Circle and neighboring reservations; one at McPherson and Farragut Squares; one at Stanton Square and neighboring reservations; two at Henry Square and Seaton Square and reservations east of Botanic Garden; one at Mount Vernon Square and adjacent reservations; one for the greenhouses and nursery; one at grounds south of Executive Mansion; eleven in all, at six hundred and sixty dollars each, seven thousand two hundred and sixty dollars.

For one night watchman at Henry Square (Armory) and Seaton Square and reservations east of Botanic Garden. seven hundred and twenty dollars.

For one night watchman at Garfield Park, seven hundred and twenty dollars.

For contingent and incidental expenses, five hundred dollars.

Contingent expenses.

* * * * * * *

Approved, July 16, 1892.

CHAP. 198.—An act to amend section seven of the act approved June twenty-second, eighteen hundred and eighty-eight, entitled "An act to authorize the construction of a bridge over the Missouri River at or near the city of Omaha, Nebraska," and for other purposes.

July 16, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section seven of the act approved June twenty-second, eighteen hundred and eighty-eight, entitled "An act to authorize the construction of a bridge over the Missouri River at or near the city of Omaha, Nebraska," is hereby amended so as to require said bridge to be completed within three years from the date of the approval of this act, and all the other provisions of said act are hereby revived and determined to be in full force and effect.

Missouri River.
Time extended for bridging, at Omaha, Nebr.
Vol. 25, p. 199.

Approved, July 16, 1892.

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July 21, 1892.

CHAP. 214.—An act granting the right of way to the Mexican Gulf, Pacific and Puget Sound Railroad Company over and through the public lands of the United States in the States of Florida, Alabama, Mississippi, and Tennessee, and granting the right of way to said railroad company over and through the United States naval and military reservations near Pensacola, in the State of Florida.

Mexican Gulf, Pacific and Puget Sound Railroad Company granted right of way through public lands in Florida, Alabama, Mississippi, and Tennessee.

Pensacola.

Use of timber, etc.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Mexican Gulf, Pacific and Puget Sound Railroad Company, a company organized under the laws of the States of Florida and Alabama, is hereby granted the right of way, one hundred feet in width, through the lands belonging to the United States in the States of Florida, Alabama, Mississippi, and Tennessee, and through the reservations lying near Pensacola, in the State of Florida, known as the naval and military reservations. The said The Mexican Gulf, Pacific and Puget Sound Railroad Company is hereby granted also the privilege and authority to use such timber, gravel, stone, and all materials within the said right of way through lands belonging to the United States, except said naval and military reservations, as may be necessary in the construction and operation of the said The Mexican Gulf, Pacific and Puget Sound Railroad.

Location through reservations, Pensacola, to be approved by Secretaries of War and Navy.

Proviso.

Track to navy-yard.

Coaling station.

Damages.

Regulation.

SEC. 2. That the line and location of the right of way to the said The Mexican Gulf, Pacific and Puget Sound Railroad Company through the naval and military reservations near Pensacola, Florida, shall be subject to the approval and under the control of the Secretary of the Navy and the Secretary of War: *Provided*, That the said railroad company, on notification by the Secretaries of the Navy and War, shall, within a reasonable time thereafter, construct, maintain, and operate at its own expense a spur track or tracks to enter into and be located at such place or places within the present limits of the navy-yard inclosure on said reservation as may be designated by the Secretary of the Navy: *And provided further*, That the Secretaries of the Navy and War be, and are hereby, authorized to allow the use by the said company, in the accommodation of its general traffic and the maintenance of a coaling station, of so much of the land and water front of the said reservation lying west of and outside the present navy-yard inclosure as in their judgment will not be required for naval or army purposes, and as will not be a hindrance to the public defense nor prejudicial to the health of those residing on the Government reservation and not to exceed in any one case three hundred feet of water front, which width may extend back along the line of said road not more than one thousand feet; the value of the use of land to be appraised by a board of naval officers, to be appointed by the Secretary of the Navy: *And provided further*, That said company shall reimburse the residents of said reservation for any damages to their property or tenements caused by the construction, excavation, or operation of said road, such damage in all cases to be fixed by the said board: *And provided further*, That the right of way and other privileges granted in this section shall be subject to the regulation and control of the said Secretaries, and shall be inoperative, null, and void unless the said railroad company shall complete the construction of and have in use its tracks within two years from the date of the passage of this act.

Removal of structures.

Structures to be approved by Secretaries of War and Navy.

SEC. 3. That the Secretaries of the Navy and War may, at any time they shall deem it necessary for the public good, cause to be removed or destroyed all or any of the structures hereby permitted on the naval and military reservations near Pensacola, Florida, without liability for damages; and the said company shall not erect or allow the use of any residences on said reservation, nor shall it erect any structures of any kind thereon, except such as the Secretaries of the Navy and War shall approve; and all approvals in this act required shall be in writing.

Amendment, etc.

SEC. 4. That Congress expressly reserves the right to alter, amend, or repeal this act, in whole or in part, without any liability on the part of the United States for any damages or losses sustained by said company.

Approved, July 21, 1892.

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CHAP. 233.—An act making appropriations for fortifications and other works of defense, for the armament thereof, for the procurement of heavy ordnance for trial and service, and for other purposes.

July 23, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the sums of money herein provided for be, and the same are hereby, appropriated out of any moneys in the Treasury not otherwise appropriated, to be available until expended, namely:

Fortifications appropriations.

GUN AND MORTAR BATTERIES: For construction of gun and mortar batteries, five hundred thousand dollars.

Gun and mortar batteries.

SITES FOR FORTIFICATIONS AND SEACOAST DEFENSES: For the procurement of land, or right pertaining thereto, needed for the site, location, construction, or prosecution of work for fortifications and coast defenses, five hundred thousand dollars, or so much thereof as may be necessary.

Sites.

PRESERVATION AND REPAIR OF FORTIFICATIONS: For the protection, preservation, and repair of fortifications for which there may be no special appropriation available, sixty thousand dollars.

Preservation, etc.

For preparation of plans for fortifications, five thousand dollars.

Plans.

* * * * * * *

That the President is hereby authorized to appoint a board, to consist of three officers of the Army and three officers of the Navy, who shall examine and report to the Secretary of War for transmission to Congress for its consideration what, in their opinion, is the most suitable site on the Pacific Coast or on the rivers or other waters thereof, for the erection of a plant for finishing and assembling the parts of heavy guns and other ordnance for the use of the Army and Navy. That for the payment of the necessary expenses of the board to be appointed under the foregoing provisions the sum of two thousand five hundred dollars is hereby appropriated out of any money in the Treasury not otherwise appropriated.

Commission to report on site for gun plant, etc., Pacific Coast.

* * * * * * *

For the following, to be expended under the direct supervision of the Board of Ordnance and Fortification, created by the fortifications appropriation act approved September twenty-second, eighteen hundred and eighty-eight, and in the manner prescribed by said act, namely:

Board of Ordnance and Fortification.

Vol. 25, p. 489.

* * * * * * *

BOARD OF ORDINANCE AND FORTIFICATION: To enable the board to make all needful and proper purchases, experiments and tests to ascertain, with a view to their utilization by the Government, the most effective guns, small arms, cartridges, projectiles, fuses, explosives, torpedoes, armor plates, and other implements and engines of war, and to purchase or cause to be manufactured under authority of the Secretary of War, such guns, carriages, armor plates, and other war materials and articles as may, in the judgment of the Board, be necessary in the proper discharge of the duty devolved upon it by the act approved September twenty-second, eighteen hundred and eighty-eight; to pay the salary of the civilian member of the Board of Ordnance and Fortification provided by the act of February twenty-fourth, eighteen hundred and ninety-one, and for the necessary traveling expenses of said member when traveling on duty as contemplated in said act; for payment of the necessary expenses of the Board, including a per diem allowance to each officer detailed to serve thereon when employed on duty away from his permanent station of two dollars and fifty cents a day; and for the test of experimental guns and carriages procured in accordance with the recommendations of the Board of Ordnance and Fortification, two hundred and ten thousand dollars.

Purchases, tests, etc.

Vol. 25, p. 489.

Civilian member.

Vol. 26, p. 769.

Expenses.

That all material purchased under the foregoing provisions of this act shall be of American manufacture, except in cases when, in the judgment of the Secretary of War, it is to the manifest interest of the United States to make purchases in limited quantities abroad, which material shall be admitted free of duty.

Purchases to be of American manufacture. Exception.

Approved, July 23, 1892.

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July 23 1892.

CHAP. 237.—An act to accept a bequest made by General George W. Cullom for the erection of a memorial hall at West Point, New York, and to carry the terms and conditions of the same into execution.

Preamble.

Whereas George W. Cullum, colonel of the Corps of Engineers on the retired list, brevet major-general United States Army, a resident of the city of New York, lately deceased, did, by his last will and testament, give and bequeath to the United States the sum of two hundred and fifty thousand dollars upon the terms and conditions that the United States shall build and maintain, in accordance with certain stipulations, upon the public grounds at West Point, New York, a fire-proof memorial hall for certain designated purposes hereinafter specified: Therefore,

Military Academy. Acceptance of bequest by Gen. G. W. Cullum for memorial hall.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the said bequest be, and the same hereby is, accepted by the United States under the terms and conditions thereto annexed by the said testator in his said last will and testament; the said sum of two hundred and fifty thousand dollars to be paid into the Treasury of the United States, subject to the disposition hereinafter to be made of the same and for the faithful execution of the objects and purposes of said bequest according to the will of the donor.

Board of trustees.

SEC. 2. That the Superintendent of the United States Military Academy, three other members of the academic board, and Major-General James B. Fry, during his lifetime, be, and they are, constituted a board, by the name of "The Board of Trustees of the Memorial Hall of the United States Military Academy," whose duty it shall be to erect the said memorial hall according to the provisions of the will of the testator, and on completion thereof to transfer the same to the United States for perpetual use as a memorial hall, to be devoted to the objects and purposes as defined in the said will. And the members of the said board of trustees, to be selected as aforesaid, shall be appointed, immediately upon the passage of this act, by the Secretary of War, from the members of the academic board of the said academy who are graduates thereof. And in the event of any vacancy occurring in the said board of trustees, either by the death or inability to serve of Major-General James B. Fry, or by the death or vacation of office of any member thereof who was appointed by selection from the members of the said academic board, the Secretary of War shall in each case, and from time to time as often as vacancies occur, fill such vacancy by the appointment of a member of the said academic board, who shall be a graduate of the said Military Academy, in the same manner as provided for in the original appointment.

Duties.

Vacancies.

Erection of building.

SEC. 3. That when the said sum of two hundred and fifty thousand dollars shall have been paid into the Treasury of the United States the whole sum shall be, and hereby is, appropriated for the erection of a suitable structure for the purposes of a memorial hall at West Point, New York, upon such site at West Point, New York, as the board of trustees herein created shall recommend and the Secretary of War approve.

Plans to be submitted by board of trustees.

SEC. 4. That the said board of trustees shall, as soon as practicable after the funds appropriated for building purposes in the preceding section shall have become available, determine, by a majority of the whole number of its members, upon a plan and specifications for a building to be erected corresponding to and in accordance with the terms and conditions of the aforesaid bequest, and submit the same to the Secretary of War for his approval, who on behalf of the United States shall then cause a contract to be let, in the same manner as other contracts to which the United States is a party, for the erection of said building, under the direction of the said board of trustees.

Approval by Secretary of War.

Use of funds. R. S., sec. 3673 p. 722.

SEC. 5. That the funds appropriated in this act shall be drawn from the Treasury as required by section thirty-six hundred and seventy-three, Revised Statutes of the United States, in the case of moneys appropriated for the use of the War Department. And the said board of trustees shall submit to the Secretary of War es-

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timates for his approval, which shall form the basis of his requisition. The funds so drawn shall be disbursed, under the direction of the Secretary of War, by the disbursing officer of the United States Military Academy, upon vouchers certified to by the president and secretary of the said board of trustees for and in behalf of said board, and shall be accounted for by the said disbursing officer in the same manner and under the same conditions as other public funds of the United States: *Provided*, That the authority of the Secretary of War for any expenditure under the provisions of this act shall be conclusive evidence of the legality thereof.

Proviso.
Approval of Secretary of War final.

SEC. 6. That the memorial hall to be erected under the provisions of this act shall be a receptacle of statues, busts, mural tablets, and portraits of distinguished and deceased officers and graduates of the Military Academy, of paintings of battle scenes, trophies of war, and such other objects as may tend to give elevation to the military profession; and to prevent the introduction of unworthy subjects into this hall the selection of each shall be made by not less than two-thirds of the members of the entire academic board of the United States Military Academy, the vote being taken by ayes and nays and to be so recorded.

Purpose of the memorial hall.

SEC. 7. That the said board of trustees shall, within thirty days after the passage of this act, meet at West Point, New York, and organize by the election of one of their number as president and another as secretary of said board; and a majority of the whole number shall constitute a quorum for the transaction of business. And the said memorial hall shall be erected under the direction of the said board of trustees, and after being erected shall be maintained, managed, and controlled by the United States in a manner similar to other public buildings at West Point. After the construction of the building and its transfer to the Government the functions of the said board of trustees shall cease.

Organization of trustees.

Termination of duties.

Approved, July 23, 1892.

CHAP. 240.—An act to establish a division line between land of the United States and the Pittsburg, Fort Wayne and Chicago Railroad Company.

July 23, 1892.

Whereas a conflict has arisen between the United States and the Pittsburg, Fort Wayne and Chicago Railroad Company as to the true location of the division line between land owned by them respectively on the north shore of Ohio River adjacent to the Davis Island Dam, in Allegheny County, Pennsylvania; and

Preamble.

Whereas the following described compromise line of division between said properties is satisfactory to the United States, to wit: Beginning at a stone monument, A, in the western boundary line of property acquired by the United States of America from William Jackman, said property line being the former division line between properties of William Jackman and Alexander Taylor, said monument being located sixteen and eight-hundredths feet from the south rail of the present south main track of said Pittsburg, Fort Wayne and Chicago Railway, measured on the boundary line, said stone monument being also ten feet (measured at right angles) from the future south rail of future south main track of Pittsburg, Fort Wayne and Chicago Railway as located; thence south forty-four degrees and forty minutes east, five hundred eighty-one and three-tenths feet to a stone monument, B, located thirty-one and eight-tenths feet northeast from the inner-face wall of the western gate recess, Davis Island Dam; thence continuing south forty-four degrees and forty minutes east, to a point southeastwardly from said stone monument, B, seven and six-tenths feet; thence north forty-five degrees and thirty minutes east, five and ninety-two hundredths feet to a point; thence south forty-four degrees and forty minutes east, fifty-four and eight-tenths feet to a point; thence south forty-five degrees and thirty minutes west five and ninety-two hundredths feet to a point on the compromise (or dividing-line; thence south forty-four degrees and forty minutes

east two hundred eight and five-tenths feet to a point twenty-one and two-tenths feet distant northwardly from the northwest corner of lock-keeper's house; thence continuing by same course and straight line eighty-six and eight-tenths feet to a point twenty and eight-tenths feet distant northwardly from the northeast corner of lock-keeper's house; thence continuing by same course and straight line one hundred and fifty-six and seven-tenths feet to a stone monument, C; thence southeastwardly by a curved line, radius eight thousand five hundred and ninety-four feet, a distance of one hundred and nineteen and seven-tenths feet to a point thirty and three-tenths feet northeast from inner face of eastern gate recess, Davis Island Dam; thence continuing southeastwardly by same curved line six hundred and thirty-five feet to a stone monument, D; thence southeastwardly by straight line tangent to last-mentioned line a distance of one hundred and thirty-one feet to a stone monument, E, on the eastern boundary line of property of the United States of America acquired from Thomas Mulvehill: Therefore,

Davis Island Dam, Pa. Settlement of division line with Pittsburg, Fort Wayne and Chicago Railroad Company.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the United States of America do consent to the division line hereinbefore recited and specified between their land and that of the Pittsburg, Fort Wayne and Chicago Railroad Company on the north shore of the Ohio River at the Davis Island Dam upon the relinquishment and conveyance by the said railroad company of all its right, title, and interest in and to the property on the south or river side of said recited line to the United States; and upon such relinquishment and conveyance to the United States in a manner valid and satisfactory to the Attorney-General of the United States do hereby release and convey all their right, title, and interest in and to the property north of said recited line to the said Pittsburg, Fort Wayne and Chicago Railroad Company: *Provided*, That no spare material shall be stored south of the proposed new track of the said railroad company for a space of seven hundred and thirty feet, beginning fifty feet above the upper gate recess and ending fifty feet below the lower gate recess: *Provided also*, That the said railroad company shall construct a walk of crushed limestone, such as is used at its stations, from Bellevue Station to the lock house: *And provided also*, That the said railroad company shall protect the ends of the recesses, if necessary, by masonry walls.

Provisos. Storage of material. Walk. Masonry walls.

Approved July 23, 1892.

July 23, 1892.

CHAP. 241.—An act to establish a railroad bridge across the Black River, in Arkansas.

Hoxie and Pocahontas Railroad Company may bridge Black River at Pocahontas, Ark.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Hoxie and Pocahontas Railroad Company, a corporation organized under the laws of the State of Arkansas, its successors and assigns, are hereby authorized and empowered to erect, establish, and maintain a railroad bridge across the Black River in the State of Arkansas, between a point on the east side of said river, in the county of Randolph in said State, to be by said company selected, and at a point to be also selected by said company at or near the town of Pocahontas on the west side of said Black River, in said county of Randolph and State of Arkansas; and that said bridge shall not interfere with the free navigation of said river, and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, the same shall be instituted and determined in the district court of the United States for the eastern district of the State of Arkansas.

Unobstructed navigation. Litigation.

Construction.

SEC. 2. That any bridge built under the provisions of this act may, at the option of the company building the same, be built as a drawbridge, with a pivot or other form of draw, or with unbroken

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or continuous spans: *Provided*, That if the said bridge shall be built with unbroken or continuous spans it shall have one or more channel spans, each having not less than two hundred feet clear channel way, measured normal to the current of said river, and not less than fifty feet clear headroom above high-water mark, and the clear headroom under the other channel spans may be less than fifty feet: *Provided*, That no part of the superstructure of such spans shall give a less headroom than ten feet above high-water mark: *And provided further*, That the interests of navigation be not injured by such reduction in height; and the piers of said bridge shall be parallel with the current of said river, and the main span shall be over the main channel of the river, and not less than two hundred feet in length: *And provided also*, That if any bridge built under this act shall be constructed as a drawbridge, the same shall be constructed as a pivot drawbridge, with a draw over the main channel of the river at an accessible and navigable point and with spans of not less than one hundred feet in length, measured normal to the current of said river, on each side of the central or pivot pier of the draw; and the next adjoining spans to the draw shall not be less than two hundred feet in length, measured normal to the current of said river, and every part of the superstructure shall give a clear headroom of not less than ten feet above high watermark: *Provided*, That the spans of both high and low bridges shall be so located as to afford the greatest possible accommodations to the river traffic, and a draw opening of low bridges shall, if practicable, be located next or near shore; and the piers of said bridge shall be parallel with the current of the river when said bridge may be erected: *And provided also*, That said draw shall be opened promptly upon reasonable signal for the passage of boats: *And provided also*, That if the approaches by land to said bridge shall be built over land submerged at high water, said approaches shall be provided with sufficient passage for water, in connection with the water way through the spans of said bridge, to pass the flood discharge of the Black River without unduly increasing the velocity of flow through the navigated spans of said bridge: *And provided also*, That all such dikes, booms, piers, fences, wing dams, and other necessary works that may be necessary to safely guide all steamboats, rafts, tows, and other water craft navigating said river, up to and through said draw or channel spans at any and all stages of water in the Black River, within the distance of one mile above and one-half mile below said bridge shall be located, constructed, and maintained at all times as may be required by the Secretary of War: *And provided also*, That the approaches of said bridge by land or by water within the limits of high water with limiting and level lines of the natural surface, grades of track, and proposed high-water discharge openings, within said overflowed limits along the line of such road or any road using said bridge and all accessory works herein required among other data hereinafter required shall be indicated, shown and located upon the maps and plans of said bridge, hereinafter required to be submitted for approval to the Secretary of War.

Proviso. Spans. Height. Piers, etc. Draw. Location of spans. Opening draw. Approaches. Aids to navigation. Maps to show approaches, etc.

SEC. 3. That any bridge constructed under this act and according to its limitation shall be a lawful structure, and shall be known and recognized as a post route, and the same is hereby declared to be a post route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for their transportation over the railroads and public highways leading to the said bridge, and the United States shall have the right of way for a postal telegraph across said bridge.

Lawful structure and post route. Postal telegraph.

SEC. 4. That all railway companies desiring to use said bridge shall have and be entitled to equal rights and privileges in the passage of the same and in the use of the machinery and fixtures thereof, and of the approaches thereto, under and upon such terms and conditions as shall be prescribed by the Secretary of War upon hearing the allegations and proofs of the parties in case they shall not agree.

Use by other companies. Terms.

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Secretary of War to approve plans, etc.

SEC. 5. That the structure herein authorized shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of said bridge and approaches by land and by water, and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the current at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge and approaches thereto are approved by the Secretary of War the bridge shall not be commenced or built, and should any change be made in the plan of said bridge during the process of construction such change shall be subject to the approval of the Secretary of War; and the said structure shall be at all times so managed and kept as to offer reasonable and proper means for the passage of vessels through or under said structure; and to secure the safe passage of vessels at night there shall be displayed on said bridge, from the hour of sunset to that of sunrise, such lights as may be prescribed by the Light-House Board; and the said structure shall be changed, at the cost and expense of the owners thereof, from time to time, as the Secretary of War may direct, so as to preserve the free and convenient navigation of said river.

Changes.

Lights.

Commencement and completion.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date thereof.

Amendment.

SEC. 7. That the right to alter, amend, or repeal this act is hereby expressly reserved.

Approved, July 23, 1892.

July 26, 1892.

CHAP. 248.—An act to enforce reciprocal commercial relations between the United States and Canada, and for other purposes.

Canadian canals.

President to suspend free passage through Saint Marys Falls Canal when unjust charges are made for navigation of Saint Lawrence River, etc., by United States vessels, etc.

See Procs., p. 54.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That, with a view of securing reciprocal advantages for the citizens, ports, and vessels of the United States, on and after the first day of August, eighteen hundred and ninety-two, whenever and so often as the President shall be satisfied that the passage through any canal or lock connected with the navigation of the Saint Lawrence River, the Great Lakes, or the water ways connecting the same, of any vessels of the United States, or of cargoes or passengers in transit to any port of the United States, is prohibited or is made difficult or burdensome by the imposition of tolls or otherwise which, in view of the free passage through the Saint Marys Falls Canal, now permitted to vessels of all nations, he shall deem to be reciprocally unjust and unreasonable, he shall have the power, and it shall be his duty, to suspend, by proclamation to that effect, for such time and to such extent (including absolute prohibition) as he shall deem just, the right of free passage through the Saint Marys Falls Canal, so far as it relates to vessels owned by the subjects of the government so discriminating against the citizens, ports, or vessels of the United States, or to any cargoes, portions of cargoes, or passengers in transit to the ports of the government making such discrimination, whether carried in vessels of the United States or of other nations.

Tolls.

In such case and during such suspension tolls shall be levied, collected, and paid as follows, to wit: Upon freight of whatever kind or description, not to exceed two dollars per ton; upon passengers, not to exceed five dollars each, as shall be from time to time determined by the President: *Provided*, That no tolls shall

Proviso.

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be charged or collected upon freight or passengers carried to and landed at Ogdensburg, or any port west of Ogdensburg, and south of a line drawn from the northern boundary of the State of New York through the Saint Lawrence River, the Great Lakes, and their connecting channels to the northern boundary of the State of Minnesota.

No charge for navigation west of Ogdensburg, N. Y.

SEC. 2. All tolls so charged shall be collected under such regulations as shall be prescribed by the Secretary of the Treasury, who may require the master of each vessel to furnish a sworn statement of the amount and kind of cargo and the number of passengers carried and the destination of the same, and such proof of the actual delivery of such cargo or passengers at some port or place within the limits above named as he shall deem satisfactory; and until such proof is furnished such freight and passengers may be considered to have been landed at some port or place outside of those limits, and the amount of tolls which would have accrued if they had been so delivered shall constitute a lien, which may be enforced against the vessel in default wherever and whenever found in the waters of the United States.

Collection of tolls.

Proof of destination.

Tolls to be a lien.

Approved, July 26, 1892.

CHAP. 258.—An act to amend "An act to authorize the construction of a bridge across the Tennessee River at or near Knoxville, Tennessee," approved August ninth, eighteen hundred and eighty-eight.

July 26, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time for the commencement of the bridge authorized by an act entitled "An act to authorize the construction of a bridge across the Tennessee River at or near Knoxville, Tennessee," approved August the ninth, eighteen hundred and eighty-eight, be, and the same is hereby, extended one year from this passage of this act, and that the time for the completion of said bridge be extended three years from the same date.

Bridge across Tennessee River at Knoxville, Tenn.

Vol. 25, p. 395.

Time for construction extended.

Approved, July 26, 1892.

CHAP. 265.—An act to authorize the construction of a bridge across the Savannah River.

July 27, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of the United States of America is hereby given to the Middle Georgia and Atlantic Railway Company, a corporation incorporated by the laws of the State of Georgia, its successors and assigns, and such other persons as may be associated with it, to construct and maintain a bridge over the Savannah River from the main land to Hutchinson Island, in the county of Chatham.

Middle Georgia and Atlantic Railway Company may bridge Savannah River to Hutchinson Island, Georgia

SEC. 2. That the bridge shall be so constructed, by draw-span or otherwise, that a free and unobstructed passage may be secured to all vessels and other water craft navigating said river. That any bridge constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company shall submit to the Secretary of War, for his examination and approval, the design and drawings of the bridge, piers, and approaches, and a map of the location, giving, for the space of at least one mile above and one mile below the proposed location, the topography of the banks of the river, the shore lines at high water and at low water, and the direction and strength of the currents at all stages, and the sound-

Construction

Secretary of War to approve plans, etc.

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ings, accurately showing the bed of the stream, and the location of other bridge or bridges, wharves, landings, or ferries, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and until said plan and location of the bridge are approved by the Secretary of War the bridge shall not be commenced or built, and after such approval by the Secretary of War the approved plans and designs for the bridge shall not be deviated from or added to either during the construction or after the completion of the bridge until the proposed change shall have been submitted to the Secretary of War and received his approval; and the said bridge shall be at all times so kept and managed as to offer reasonable and proper means for the passage of vessels through or under said bridge, and if said

Opening draw.

bridge be built with a draw said draw shall be opened promptly upon reasonable signal for the passage of boats or other craft, and the said company or corporation shall maintain, at its own expense,

Lights, etc.

from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe; and if at any time the

Unobstructed navigation.

navigation of said river shall in any manner be obstructed or impaired by the bridge authorized by this act to be constructed, the Secretary of War shall have authority, and it shall be his duty, to require said company to alter and change said bridge, at its own expense, in such manner as may be proper to secure free and complete navigation without impediment; and if upon reasonable notice to said company, its successors or assigns, to make such change or improvements, the said company fails to do so, the Secretary of War shall have authority to make the same, and shall thereupon

Litigation.

institute proceedings in the circuit court of the United States in and for the district in which any part of said bridge may be located

Proviso.

Existing laws not affected.

for the recovery of the cost thereof: *Provided, also*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operations of the same.

Lawful structure and post-route.

SEC. 3. That any bridge built under this act and subject to its limitations shall be a lawful structure and shall be recognized and known as a post-route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops and munitions of war of the United States, or passengers or freight over said bridge than the rate per mile paid for the transportation over the railroads or public highways leading to said bridge, and it shall enjoy the rights and privileges of other post roads of the United States. And equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies, and the United States shall have the right of way across said bridge and

Postal telegraph.

its approaches for said postal-telegraph purposes.

Use by other companies.

SEC. 4. That all railroad companies desiring the use of said bridge and its approaches shall have and be entitled to equal rights and privileges relative to the passage of trains over the

Terms.

same upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any of them, desiring such use shall fail to agree upon the sum or sums to be paid or upon rules and conditions to which each shall conform in using said bridge and approaches, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties.

Amendment, etc.

SEC. 5. That the right to alter, amend, or repeal this act is hereby expressly reserved, and the right to require any changes in said structure, or its removal, at the expense of the owners thereof, whenever the Secretary of War shall decide that the public interest requires it, is also expressly reserved.

Commencement and completion.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date hereof.

Approved July 27, 1892.

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CHAP. 269.—An act amending the act of October first, eighteen hundred and ninety, entitled "An act to provide for the examination of certain officers of the Army and to regulate promotions therein."

July 27, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section three of the act of October first, eighteen hundred and ninety, entitled "An act to provide for the examination of certain officers of the Army and to regulate promotions therein," is hereby amended by adding thereto the following: *And provided further*, That officers entitled by this section to examination by a board composed entirely of officers who were appointed from civil life, or who were officers of volunteers only during the war, may, by written waiver filed with the War Department, relinquish such right, in which case the examination of such officers shall be conducted by boards composed as shall be directed by the Secretary of War.

Army. Promotions. Vol. 26, p. 562.

Officers appointed from civil life may waive board of similar character.

SEC. 2. That the examination of officers of the Corps of Engineers and Ordnance Department who were officers or enlisted men in the regular or volunteer service, either in the Army, Navy, or the Marine Corps, during the war of the rebellion, shall be conducted by boards composed in the same manner as for the examination of other officers of their respective corps and department; and the examinations shall embrace the same subjects prescribed for all other officers of similar grades in the Corps of Engineers and Ordnance Department, respectively.

Examination of engineer or ordnance officers who served during the rebellion.

Subjects.

Approved, July 27, 1892.

CHAP. 271.—An act to authorize the construction of jetties, piers, and breakwaters at private expense in the Gulf of Mexico, at the mouth of Ropes Pass, in the State of Texas.

July 27, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Port Ropes Company, a corporation existing under the laws of the State of Texas, which has partially constructed a ship channel across Mustang Island, in said State, for the purpose of obtaining a deep-water harbor upon the coast of Texas, at its own cost and expense, by connecting the waters of Corpus Christi Bay with those of the Gulf of Mexico, be, and is hereby, authorized to protect the gulf entrance to said ship channel, and to further prosecute its project of obtaining and maintaining a deep-water harbor, by constructing suitable jetties, piers, and breakwaters as far out into the waters of the Gulf of Mexico as may be requisite to obtain and maintain a channel with a depth of thirty feet, more or less.

Port Ropes Company may construct jetties, etc., Mustang Island, Texas.

SEC. 2. That said work shall be prosecuted by the said the Port Ropes Company, its successors and assigns, diligently, and completed within seven years from the passage of this act and entirely at its own expense, and nothing in this act shall be construed as committing the Government of the United States to any expenditure for the whole or any part of the same. And the said company shall hold the United States harmless from any damage that may accrue to any person or persons by reason of the construction of its work.

Completion.

United States not liable for damages, etc.

SEC. 3. That at any time after said improvements and works have been completed as herein provided, and a depth of twenty feet has been obtained, the United States shall have the right to pay the said company, or their assigns, successors, or legal representatives, the value of the works constructed under this act or under or by virtue of any authority granted by the State of Texas, which value shall be ascertained by appraisement to be made by three officers of the Engineer Corps of the United States Army, who shall be appointed for that purpose by the Secretary of War, and on such payment being made by the United States all rights to said work on the part of said parties shall cease; but nothing in this act shall be

United States may purchase works on completion.

Appraisement

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Purchase not compulsory.

construed as compelling or requiring the Government to take possession of and pay for said works unless so desired by the Government of the United States.

Amendment.

SEC. 4. That Congress may at any time alter, amend, or repal this act.

Approved, July 27, 1892.

July 27, 1892.

CHAP. 274.—An act to build a bridge across the Tennessee River between a point in Whitesburg Precinct, in Madison County, and Morgan County, in the State of Alabama.

Huntsville Bridge Company may bridge Tennessee River, Alabama.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Huntsville Bridge Company, a corporation duly organized and existing under the laws of the State of Alabama, its successors or assigns, be, and are hereby, authorized to construct and maintain a bridge, and approaches thereto, across the Tennessee River between a point in Whitesburg Precinct, in Madison County, and Morgan County, in the State of Alabama. Said bridge shall be constructed to provide for the passage of railroad trains, wagons, and vehicles of all kinds, steam and street cars, animals, foot passengers, and for all road travel, for such reasonable rates of toll and under such reasonable rules and regulations as may be prescribed by said corporation, its successors or assigns, and approved by the Secretary of War.

Railroad, wagon, and foot bridge.

Toll, etc.

Lawful structure and post route.

SEC. 2. That any bridge built under this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroad or public highways leading to said bridge, and it shall enjoy the rights and privileges of other post roads in the United States; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies, and the United States shall have the right of way across said bridge and its approaches for postal and telegraph purposes.

Postal telegraph.

Ponton draw.

SEC. 3. That said bridge shall be constructed as a ponton drawspan bridge, and shall contain a ponton drawspan of not less than two hundred feet in length, which drawspan shall be maintained over the main channel of the river at an accessible and navigable point, and the piers of said bridge shall be parallel with and the bridge itself at right angles to the current of the river: *Provided*, That said draw shall be opened promptly by said company or corporation upon reasonable signal for the passage of boats and rafts, and said company or corporation shall maintain, at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe. No bridge shall be erected or maintained under the authority of this act which shall at any time obstruct the free navigation of said river, and if any bridge erected under such authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause the entire removal thereof or such change or alteration of such bridge to be made as will effectually obviate such obstruction, and all such alterations shall be made and all such obstructions shall be removed at the expense of the owner or owners of said bridge, and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river caused or alleged to be caused by said bridge, the case may be brought in the district court of the United States in the State of Alabama in whose jurisdiction any portion of said obstruction or bridge may be located: *Provided further*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of the law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operations of the same: *Provided*,

Provisos.
Opening draw.

Lights, etc.

Unobstructed navigation.

Litigation.

Existing laws not affected.

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That said company may construct a wagon and foot bridge alone, and in case of the construction of a wagon and foot bridge alone the drawspan shall be of such length and shall be of such construction as shall be approved by the Secretary of War, and shall be subject to all the provisions herein contained in respect to being promptly opened to admit of the unobstructed navigation of said river, and of keeping the said bridge lighted as herein provided in case of a railroad and wagon bridge, and in such case the provisions herein in relation to the use for railroad purposes shall not apply.

Wagon and foot bridge provisions.

SEC. 4. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railroad trains or cars over the same, and over the approaches to the same, upon the payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any of them, desiring such use, shall fail to agree upon the sum or sums to be paid, and upon the rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties.

Use by railroad companies.

Compensation.

SEC. 5. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his approval and examination, a design and drawings of the bridge, and a map of the location, giving for the space of one-half mile above and one-half mile below the proposed location the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be commenced or built; and should any change be made in the plans of said bridge during the progress of its construction, such changes shall be subject to the approval of the Secretary of War.

Secretary of War to approve plans, etc.

Changes.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the time this act takes effect: *Provided*, That Congress reserves the right to alter, amend, or repeal this act whenever it may think the public interests so require.

Commencement and completion.

Proviso.

Amendment, etc.

Approved, July 27, 1892.

CHAP. 275.—An act to provide for the improvement of the outer bar of Brunswick, Georgia.

July 27, 1892.

Brunswick, Ga.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be authorized to pay to C. P. Goodyear, his heirs or assigns, upon the procurement by said C. P. Goodyear, his heirs or assigns, of a practicable channel over the outer bar of Brunswick, Georgia, at least one hundred feet in width and of a minimum depth of twenty-two feet at ordinary mean high tide, on or before November first, eighteen hundred and ninety-two, the sum of ten thousand dollars; upon the procurement as aforesaid on or before January first, eighteen hundred and ninety-three, of a depth of water in said channel over said outer bar of a minimum depth at ordinary mean high tide of twenty-three feet, ten thousand dollars more, to be paid in manner aforesaid; upon the procurement as aforesaid on or before March first, eighteen hundred and ninety-three, of a depth of water in said channel over said outer bar at a minimum depth at ordinary mean high tide of twenty-four feet, ten thousand dollars more, to be paid in manner aforesaid; upon

Payments to C. P. Goodyear upon securing deep-water channel over outer bar.

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the procurement as aforesaid on or before May first, eighteen hundred and ninety-three, of a depth of water in said channel over said outer bar of a minimum depth at ordinary mean high tide of twenty-five feet, ten thousand dollars more, to be paid in manner aforesaid; upon procurement on or before October first, eighteen hundred and ninety-three, of a minimum depth in said channel over said outer bar of twenty-six feet at ordinary mean high tide, and of a width of not less than one hundred and twenty-five feet, ten thousand dollars more, to be paid in manner aforesaid; and should the depth of twenty-five feet at ordinary mean high tide in said channel over said outer bar be procured on or before the time aforesaid and maintained for two years for the width named thereafter, twenty-five thousand dollars in addition, to be paid in manner aforesaid; and should the depth of twenty-six feet at ordinary mean tide for the width named be procured on or before the date named and maintained for two years thereafter, twenty-five thousand dollars in addition, to be paid in manner aforesaid. The said C. P. Goodyear, his heirs and assigns, shall perform said work on said outer bar by the explosion of dynamite on the bottom of said channel or sunk beneath the bottom of said channel, in his or their discretion, and not otherwise; and the channel to be deepened as aforesaid shall be north of the present buoyed-out channel, so that said work shall not interfere with the commerce of the port of Brunswick during the progress of such work. The Secretary of War shall detail an officer of engineers to examine and report upon said work from time to time, at such times as the said C. P. Goodyear, his heirs and assigns, announce that they have complied with the conditions as to any of the depths and widths named, or as to the maintenance of depths of twenty five and twenty-six feet, and payments to be made as aforesaid upon the certificate of such engineer that such depth and width or such maintenance has been accomplished in accordance with the provisions of this act. And the money necessary to carry out the provisions of this act is hereby appropriated out of any money in the Treasury not otherwise appropriated.

Work to be done by exploding dynamite.

Engineer officer to report on maintenance, etc.

Appropriation.

Approved, July 27, 1892.

July 28, 1892.

CHAP. 311.—An act making appropriations to supply deficiencies in the appropriations for the fiscal year ending June thirtieth, eighteen hundred and ninety-two, and for prior years, and for other purposes.

Deficiencies appropriations.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, to supply deficiencies in the appropriations for the fiscal year eighteen hundred and ninety-two, and for prior years, and for other objects hereinafter stated, namely:

* * * * * * *

District of Columbia.

DISTRICT OF COLUMBIA.

Engineer Commissioner.

EXECUTIVE OFFICES: For one Engineer Commissioner (to make salary five thousand dollars) nine hundred and fifty-nine dollars and eighty-one cents.

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P street bridge to be repaired by Metropolitan Railroad Company.

That the Metropolitan Railroad Company is hereby required to repair the bridge across Rock Creek at P street, in the District of Columbia, at a cost of not exceeding fifteen thousand dollars. Said repairs to make the bridge sufficiently strong to allow the passage of storage-battery cars of the said company, and to be made under the direction of the Engineer Commissioner of the District of Columbia, and in accordance with plans and specifications prepared by him.

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WAR DEPARTMENT. War Department.

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JUDGMENTS, COURT OF CLAIMS.

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FOX AND WISCONSIN RIVER IMPROVEMENT. Fox and Wisconsin Rivers improvement.

For payment of the judgments and awards rendered against the United States for flowage damages caused by the improvement of the Fox and Wisconsin Rivers, in the State of Wisconsin, under the act approved March third, eighteen hundred and seventy-five, as reported to Congress by the Attorney-General, and fully set forth in House Executive Document numbered Two hundred and twenty-two, first session of the Fifty-second Congress, one hundred and nine thousand and twenty-two dollars and thirty-three cents. Payment of flowage damages. Vol. 18, p. 506.

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CLAIMS ALLOWED BY THE THIRD AUDITOR AND SECOND COMPTROLLER. Claims allowed by Third Auditor and Second Comptroller.

WAR DEPARTMENT. War Department.

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For contingencies of fortifications, three hundred and twenty-four dollars and seventeen cents. Fortifications.

For improving harbor at San Francisco, California, twenty-two cents. San Francisco harbor, Cal.

For improving Missouri River, twenty-eight cents. Missouri River.

For Mississippi River Commission, forty-four dollars and eighty cents. Mississippi River Commission.

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CLAIMS ALLOWED BY THE THIRD AUDITOR AND SECOND COMPTROLLER. Allowed by Third Auditor and Second Comptroller.

WAR DEPARTMENT. War Department.

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For contingencies of fortifications, twenty-eight dollars. Fortifications.

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Approved, July 28, 1892.

CHAP. 316.—An act authorizing the Secretary of War to lease public property in certain cases. July 28, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That authority be, and is hereby, given to the Secretary of War, when in his discretion it will be for the public good, to lease, for a period not exceeding five years and revocable at any time, such property of the United States under his control as may not for the time be required for public use and for the leasing of which there is no authority under existing law, and such leases shall be reported annually to Congress: *Provided*, That nothing in this act contained shall be held to apply to mineral or phosphate lands. Secretary of War may lease public property not required. *Proviso.* Mineral, etc., lands excepted.

Approved, July 28, 1892.

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July 29, 1892.

CHAP. 822.—An act to incorporate the Washington and Great Falls Electric Railway Company.

Washington and Great Falls Electric Railway Company incorporated.

Incorporators.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That W. C. Codd and James F. Morrison, of the State of Maryland, and James L. Barbour, James Robbins, Smith Pettit, John G. Slater, Edwin Baltz'ey, Edward Baltzley, J. P. Clark, Simson De F. Jennings, and Edward B. Cottrell, of the District of Columbia, and their associates and successors, are hereby created a body politic and corporate, in fact and in law, by the name of the Washington and Great Falls Electric Railway Company, and by that name shall have perpetual succession, and shall be able to sue and be sued, plead and be impleaded, defend and be defended in all courts of law and equity, and may make and have a common seal, and alter the same at their pleasure; and the said corporation is hereby authorized to locate, construct, equip, maintain, and operate a continuous line of single or double track railway, and all necessary sidings, stations, switches, turn-outs, and other devices, and to operate the same by electricity through and along the following named streets, avenues, and roads, to wit: Beginning at a point, to be located by the Commissioners of the District of Columbia, west of the north end of the Aqueduct Bridge, and running thence west over the Canal road on an elevated railway of iron colums and beams, with wood cross-ties and guards, to be built so as not to interfere with the use of the Chesapeake and Ohio Canal and so as to preserve to the public the full use of the Canal road. The said company shall submit the plans of said elevated railway to the Commissioners of the District of Columbia for their approval, and no work shall be done on said railway by said company before such approval in writing. In respect of everything that may pertain to the strength of the structure and to the safety and convenience of the public the construction and operating of said elevated railway shall at all times be subject to the control and approval of the said Commissioners, and the said company shall make good to the District of Columbia all damages done by it or by its contracting agents to the Canal road and other roads belonging to the District of Columbia, and shall also make good to the District of Columbia all the costs of inspection of the company's work by the authorized agents of the said District. In respect of everything that may pertain to the safety of the United States water mains in the Canal road, the plans, the construction, and the operating of said elevated railway shall be subject to the control and approval of the Secretary of War. For the safety of travel on said Canal road, and before commencing to run its cars on said elevated railway, and subject to the inspection and approval of the Commissioners of the District of Columbia, the said company shall, at its own expense, construct a substantial masonry wall between said Canal road and the Chesapeake and Ohio Canal throughout the entire distance on said road occupied by said elevated railway; and the said company also at its own expense and within the same time and subject to the same approval and acceptance, shall pave the said portion of said road with granite blocks or vitrified brick in the best manner. From the Canal road the route of said railway is to run westerly along the top of the bluff on the north side of the Canal road, and outside and south of the southern boundary of the land of the Washington Aqueduct pertaining to the distributing reservoir, to a point on said boundary not more than six hundred feet from the western boundary of said land; thence across said land but at no point less than two hundred feet from the outer crest of the dam of said reservoir, to said western boundary; thence westwardly on a route exterior to and on the south side of the land of the United States pertaining to the Conduit road to the land of the said aqueduct pertaining to the receiving reservoir; thence through said land to a point on the land of said aqueduct near the westerly foot of Dalecarlia Hill; thence westwardly on a route exterior to and on the south side of the land of the United States pertaining to the Conduit road to

May construct electric railway.

Route.

Elevated roads.

District Commissioners to approve plans, etc.

Safety of water mains.

Wall on Canal road.

Surface road.

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Cabin John Creek, returning thence along the same line, by return tracks to the place of beginning, with the privilege of constructing a branch line, with a single or double track, from the Conduit road lands south to Chain Bridge, on land to be acquired by the corporation: *Provided*, That there shall be but one railway parallel to and near the Conduit road and there shall never be more than one double track on or over the Canal road, and all acts or parts of acts granting the use of the surface of the Canal road, or any part thereof, for laying railway tracks thereon and operating cars thereon are hereby repealed; and wherever the route specified in this act is parallel with or coincides with the route of any other railway the two companies shall maintain and use but one set of double tracks, and any violation of this provision by the said Washington and Great Falls Electric Railway Company shall operate as a repeal of this charter; and matters of dispute between the companies respecting railways parallel to the Conduit road, and affecting the same, whether in the District of Columbia or in Maryland, shall be referred to and determined by the Secretary of War, and matter in dispute between the companies respecting railways on the Canal road shall be determined upon the application of either road to any court in the District of Columbia having competent jurisdiction. The inner rail of said Washington and Great Falls Railway shall not at any place on the line of said railway be less than one hundred feet from the middle of the paved portion of the Conduit road. Wherever the said railway shall run over or across any of the lands of the United States, or any of the accessory works of the Washington Aqueduct, as provided in this act, it shall be done only on such lines, in such manner, and on such conditions as shall be approved by the Secretary of War and accepted by said company, and no works shall be done on said railway on any of said lands until after such approval and acceptance in writing. No steam cars, locomotives, or passenger or other cars for steam railways shall ever be run over the tracks of said railway within the District of Columbia or on said lands. So much of said railway as may be in the State of Maryland must first have the approval of the authorities of said State. Said company shall, before commencing work on said railway, deposit with the Treasurer of the United States to the credit of the Washington Aqueduct the sum of five thousand dollars, to defray all the expenses that may be incurred by the United States in connection with the inspection of the company's work on the lands of the Untied States and any of the company's work that may affect the interests of the United States, and in making good any damages done by said company or its works to any work or land or other property of the United States, and in completing, as the Secretary of War may deem necessary, any of the company's work that the said company may neglect or refuse to complete and that the Secretary of War may consider necessary for the safety of the Washington Aqueduct and the works pertaining thereto, including its telephone line, or for the proper drainage of the United States lands, its reservoirs and other works, or for the proper use and orderly appearance of the Conduit road; and the said company and its successors shall also deposit as aforesaid such further sums for said purposes and at such times as the Secretary of War shall direct. The said moneys shall be disbursed like other moneys appropriated for the Washington Aqueduct, and whatever shall remain of said deposits after the completion of the work for which they may be obtained shall be returned to said company with an account of their disbursement in detail. The disbursements of said deposits shall, except in case of emergency, be made only on the order of the Secretary of War. During the construction and after the completion of said railway its agents and servants, when on the public land of the United States, shall be subject to such regulations as the Secretary of War may prescribe. The provisions of this act, as far as applicable, shall apply to any extension of this railway in the State of Maryland that may be granted by the authorities of said State; and the said Washington and Great Falls Railway may

Branch line.

Proviso.

Only one railway permitted parallel to Conduit road and over Canal road.

Use of coinciding tracks.

Determining disputes.

Secretary of War to approve route, etc., across Aqueduct lands.

Deposit to defray expenses of inspection, etc.

Disbursement.

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Crossing at distributing reservoir. cross the projection of the United States land at a point on the south side of the Conduit road just west of the distributing reservoir, and the provisions of section fifteen of the act of Congress

Protection of mains, etc.

Vol. 26, p. 793.

approved February twenty-eighth, eighteen hundred and ninety-one, entitled "An act to incorporate the Washington and Arlington Railway Company, of the District of Columbia," shall control and govern all the privileges granted by this act to the Washington and Great Falls Electric Railway Company, and said section shall be held to include the Washington Aqueduct and its tunnels

Construction.

and all other works connected therewith. Said Washington and Great Falls Railway shall everywhere be constructed in a neat and substantial manner, of good material, subject, for such parts of the line as are within the jurisdiction of the Commissioners of the District of Columbia, to the supervision and approval of said Commissioners, and, for such parts of the line as are in any jurisdiction outside of the District of Columbia, to the supervision and

Gauge.

approval of the proper authorities of such jurisdiction; the gauge of the track to be the same as that of the Washington and Georgetown Railway; and the said Washington and Great Falls Railway Company shall where its tracks run on or across any street or road which is under the jurisdiction of the Commissioners of the District of Columbia, or across any other road outside of the Dis-

Paving.

trict of Columbia, pave the same between the rails and sets of rails and two feet outside thereof with such material and in such manner as shall be approved by such proper authorities, as the case may require, and shall keep the same in repair at its own expense;

Failure to repair.

and if the said corporation shall fail to make any necessary repairs within ten days after notice has been given by said authorities, the repairs shall be made by said authorities and the cost thereof, except as hereinbefore provided, if not paid voluntarily, shall be recovered by them before any court of competent jurisdiction; and the amount of such repairs shall be a lien upon all property of said company from the time the same are made until paid by the company. That the said corporation shall operate its said road by electric power, and for this purpose it is hereby authorized to

Erection of poles for wires.

erect and maintain such poles and aerial lines as may be necessary for the proper conduct of said power; such lines to be built in the

Proviso.

Protection of Government telephone line.

most perfect and substantial manner: *Provided*, That in order to prevent any danger or damage to the United States telephone line between the Great Falls of the Potomac and Washington, belonging to the Washington Aqueduct, or to its instruments, from the electric wires of said railway company, the said company shall, at all times and at its own expense, remove, change, and protect said telephone line in such manner as may be directed by the Secretary of War. The said corporation shall, before operating said railway, erect and maintain, subject to the approval of the Secretary of War, at its own expense, a neat, well-painted, and

Fence.

substantial fence, four feet in height, on each side of its tracks through the lands of the United States, and also at such places along the Conduit road as the Secretary of War may deem necessary, with suitable openings and crossings for roadways, and at such places as the Secretary of War shall consider to be required for the safety of the use of said roadways. That the said corpora-

Electric lights.

tion shall, at its own expense, maintain electric lights along the entire length of its railway during the hours after nightfall that its cars shall run, and at least until twelve o'clock and thirty minutes antemeridian, which lights shall be located so as to light all roads on and across which it shall pass, and shall be placed at such points along the proposed road as the Secretary of War shall direct, and shall also light Chain Bridge in the same manner and during the same hours. No claim for damages shall ever be made by said company or its successors in consequence of the exercise of any of the rights of the United States under this act. The construction of said railway on any street where there are or may be

Mains in streets, etc.

any mains, fixtures, or apparatus pertaining to the Washington Aqueduct shall be subject to such conditions as may be approved by the Secretary of War, which conditions must be obtained and

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be accepted in writing by said company before commencing any work on such street, and the operations of said company in respect of the safety of such mains, fixtures, or apparatus shall always be subject to the control and direction of the Secretary of War, and subject to the right of the Secretary of War or other lawful public authority to interrupt the construction or use of said railway, whenever necessary for the protection or repair of such mains, fixtures, or apparatus. Efficient signals by gong or bell shall be made by every car before and during the crossing of the Conduit road. The rate of speed at which the cars may run on said road shall not exceed five miles per hour on or across any street or road, and the fare for riding over the said road shall not exceed ten cents each way per passenger, and this amount may be divided into divisions of five cents each. The work of construction and the operating of said railway by said company on the lands of the United States shall be subject to such regulations as the Secretary of War may prescribe, and the exercise of the rights by this act granted are to terminate at the pleasure of the Secretary of War in case of persistent neglect by said company or by its successors to make the deposits or to comply with any of the conditions, requirements, and regulations aforesaid.

Signals.

Speed.

Regulation of construction and operating.

SEC. 2. * * * The company may buy, lease, or construct such passenger rooms, ticket offices, depots, workshops, and buildings as may be necessary, at such points, not on the land of the United States, along the lines as the business of the railway and the convenience of the public may require, and connect its tracks therewith; all the above subject to the approval of the proper authorities.

Passenger rooms.

* * * * * * *

SEC. 6. That the work on said road shall commence within one year from and after the passage of this act, and shall be complete its entire distance, and have cars running thereon for the accommodation of the public within two years from the passage of this act; otherwise this charter shall be null and void.

Commencement and completion.

* * * * * * *

SEC. 8. That Congress may at any time amend, alter, or repeal this act.

Amendment, etc.

Approved, July 29, 1892.

CHAP. 327.—An act to authorize the construction of a bridge over the Tennessee River at or near Deposit, Alabama.

July 30, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Gurleys and Paint Rock Valley Railroad Company, of Alabama and Tennessee, a corporation duly and legally incorporated under the laws of the States of Alabama and Tennessee, its successors or assigns, to construct and maintain a bridge over the Tennessee River at or near Deposit, in Marshal County, Alabama. Said bridge shall be constructed to provide for the passage of railway trains, and, at the option of the persons by whom it may be built, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals, and for foot passengers, for such reasonable rates of toll as may be approved from time to time by the Secretary of War.

Gurleys and Paint Rock Valley Railroad Company may bridge Tennessee River at Deposit, Ala.

Railway, etc., bridge.

SEC. 2. That any bridge built under the provisions of this act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States, or passengers or freight passing over the said bridge, than the rate per mile paid for the transportation over the railroad or public highways leading to the said bridge; and it shall enjoy the rights and privileges of other post roads in the United States; and the United States shall have the right of way across said bridge and

Lawful structure and post route.

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Postal telegraph. its approaches for postal telegraph purposes, and all telegraph and telephone companies shall have equal rights and privileges in constructing and maintaining their lines across said bridge.

Drawbridge. SEC. 3. That said bridge shall be constructed as a drawbridge; the draw or pivot pier shall be at such point in the channel of the river as the Secretary of War may direct, and the opening or passage way of said draw pier shall be so protected and arranged that water crafts can be worked through it at any and all times; and the draw span shall not be of less width, nor shall the lowest part of same be of less elevation above high water, than are the widest and highest of those authorized by Congress for any bridge over the Tennessee River; and the piers of said bridge shall be parallel with and the bridge itself at right angles to the current of the river: *Provided*, That in said bridge there shall be one span of not less than three hundred feet in the clear: *Provided also*, That said draw shall be opened promptly upon reasonable signals for the passing of boats; and said company or corporation shall maintain, at its own expense, from sunset until sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe. No bridge shall be erected or maintained under authority of this act which at any time substantially or materially obstructs the free navigation, of said river; and if any bridge erected under such authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction; and all such alterations shall be made and all such obstructions be removed at the expense of the owner or owners of said bridge, and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, the cause may be brought in the circuit court of the United States or the State of Alabama in whose jurisdiction any portion of said obstruction or bridge may be located: *Provided further*, That nothing in this act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or exempt this bridge from the operation of the same.

Draw span. *Provisos.* Length of span. Opening draw. Lights, etc. Changes, etc. Litigation. Existing laws not affected.

Use by other companies. SEC. 4. That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains over the same, and over approaches thereto, upon payment of a reasonable compensation for such use, and in case the owner or owners of said bridge and several railroad companies, or any of them desiring such use shall fail to agree upon the sum or sums to be paid and upon rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War, upon a hearing of the allegations and proofs of the parties.

Compensation.

Secretary of War to approve plans, etc. SEC. 5. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company shall submit to the Secretary of War for his examination and approval a design and drawing of the bridge, and a map of location giving for the space of one mile above and one mile below the proposed location the topography of the banks of the river, the shore lines at high and low water, the directions and strength of currents at all stages, and soundings accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject: and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be built, and if any change is required by the Secretary of War in the plan of said bridge whilst the same is in progress of construction, or after its completion, or if the entire removal of said bridge is required by him at any time, the cost of such change or removal shall be paid by the company owning or controlling said bridge.

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SEC. 6. That the right to alter, amend, or repeal this act is hereby expressly reserved. Amendment, etc.

SEC. 7. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date hereof. Commencement and completion.

Approved, July 30, 1892.

CHAP. 352.—An act relating to the limitation of the hours of daily service of laborers and mechanics employed upon the public works of the United States and of the District of Columbia. August 1, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the service and employment of all laborers and mechanics who are now or may hereafter be employed by the Government of the United States, by the District of Columbia, or by any contractor or subcontractor upon any of the public works of the United States or of the said District of Columbia, is hereby limited and restricted to eight hours in any one calendar day, and it shall be unlawful for any officer of the United States Government or of the District of Columbia or any such contractor or subcontractor whose duty it shall be to employ, direct, or control the services of such laborers or mechanics to require or permit any such laborer or mechanic to work more than eight hours in any calendar day except in case of extraordinary emergency. Hours of labor. Limited to eight hours for laborers and mechanics on Government work.

SEC. 2. That any officer or agent of the Government of the United States or of the District of Columbia, or any contractor or subcontractor whose duty it shall be to employ, direct, or control any laborer or mechanic employed upon any of the public works of the United States or of the District of Columbia who shall intentionally violate any provision of this act shall be deemed guilty of a misdemeanor, and for each and every such offense shall upon conviction be punished by a fine not to exceed one thousand dollars or by imprisonment for not more than six months, or by both such fine and imprisonment, in the discretion of the court having jurisdiction thereof. Penalty for violation by officer or contractor.

SEC. 3. The provisions of this act shall not be so construed as to in any manner apply to or affect contractors or subcontractors, or to limit the hours of daily service of laborers or mechanics engaged upon the public works of the United States or of the District of Columbia for which contracts have been entered into prior to the passage of this act. Present contracts not affected.

Approved, August 1, 1892.

CHAP. 380.—An act making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and ninety-three, and for other purposes. Aug. 5, 1892.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, for the objects hereinafter expressed, for the fiscal year ending June thirtieth, eighteen hundred and ninety-three, namely: Sundry civil expenses appropriations.

* * * * * * *

UNDER THE WAR DEPARTMENT.

Under War Department.

* * * * * * *

BUILDINGS AND GROUNDS IN AND AROUND WASHINGTON.

Buildings and grounds, D. C.

For the improvement and care of public grounds, as follows: Improvement and care.

For improvement of grounds north of Executive Mansion, one thousand dollars.

For improvement and maintenance of grounds south of the Executive Mansion, four thousand dollars.

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For ordinary care of greenhouses and nursery, two thousand dollars.

For ordinary care of Lafayette Square, one thousand dollars.

For ordinary care of Franklin Square, one thousand dollars.

For care and improvement of Monument grounds, two thousand five hundred dollars.

For continuing improvement of reservation numbered seventeen and site of old canal northwest of same, five thousand dollars:

Proviso. Condition.

Provided, That no part thereof shall be expended upon other than property belonging to the United States.

For construction and repair of post-and-chain fences, and constructing stone coping around reservations, one thousand dollars.

For manure and hauling the same, five thousand dollars.

For painting watchmen's lodges, iron fences, vases, lamps, and lamp-posts, seven hundred and fifty dollars.

For purchase and repair of seats, one thousand dollars.

For purchase and repair of tools, two thousand dollars.

For trees, tree and plant stakes, labels, lime, whitewashing, and stock for nursery, two thousand dollars.

For removing snow and ice, one thousand two hundred dollars.

For flowerpots, twine, caskets, wire, splints, moss, and lycopodium, one thousand dollars.

For care, construction, and repair of fountains, one thousand five hundred dollars.

For abating nuisances, five hundred dollars.

For improvement, care, and maintenance of various reservations, twelve thousand dollars.

For improvement, maintenance, and care of Smithsonian Grounds, including construction of asphalt roads and paths, five thousand dollars.

For improvement, care, and maintenance of Judiciary Square, including grounds around the Pension Building and asphalt roads and walks leading to Pension Building, three thousand dollars.

Limit for concrete pavements.

That under appropriations herein contained no contract shall be made for making or repairing concrete or asphalt pavements in Washington City at a higher price than two dollars and twenty-five cents per square yard for a quality equal to the best laid in the District of Columbia prior to July first, eighteen hundred and eighty-six, and with a base of not less than six inches in thickness.

Executive mansion.

For repairs and fuel at the Executive Mansion, as follows:

Repairs, fuel, etc.

For care, repair, and refurnishing the Executive Mansion, twenty thousand dollars, to be expended by contract or otherwise, as the President may determine.

For fuel for the Executive Mansion, greenhouses, and stable, three thousand dollars.

For care and necessary repair of greenhouses, five thousand dollars.

For renewing the superstructures of two greenhouses connected with the Executive Mansion, two thousand dollars.

Lighting Executive Mansion and public grounds.

LIGHTING THE EXECUTIVE MANSION AND PUBLIC GROUNDS: For gas, pay of lamp-lighters, gas fitters and laborers; purchase, erection, and repair of lamps and lamp-posts, purchase of matches, and for repairs of all kinds; fuel and lights for office, office stables, watchmen's lodges, and for the greenhouses at the nursery, fourteen thousand dollars:

Provisos. Maximum per lamp.

Provided, That for each six-foot burner not connected with a meter in the lamps on the public grounds no more than twenty-one dollars and fifty cents shall be paid per lamp for gas, including lighting, cleaning, and keeping in repair the lamps, under any expenditure provided for in this act; and said lamps shall burn not less than three thousand hours per annum; and authority is hereby given to substitute other illuminating material for the same or less price, and to use so much of the sum hereby appropriated as may be necessary for that purpose:

Burners.

Provided, That before any expenditures are made from the appropriations herein provided for, the contracting gas company shall equip each lamp

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with a self-regulating burner and tip, so combined and adjusted as to secure under all ordinary variations of pressure and density a consumption of six cubic feet of gas per hour.

For electric lights for three hundred and sixty-five nights from seven posts, at forty cents per light per night, one thousand and twenty-two dollars. Electric lights.

REPAIR OF WATER PIPES: For repairing and extending water pipes, purchase of apparatus for cleaning them, purchase of hose, and cleaning the springs and repairing and renewing the pipes of the same that supply the Capitol, the Executive Mansion, and the building for the State, War, and Navy Departments, two thousand five hundred dollars. Repair of water pipes, etc.

TELEGRAPH TO CONNECT THE CAPITOL WITH THE DEPARTMENTS AND GOVERNMENT PRINTING OFFICE: For care and repair of existing lines, one thousand five hundred dollars. Telegraph, Capitol, Departments, and Government Printing Office.

WASHINGTON MONUMENT: For the care and maintenance of the Washington Monument, namely: For one custodian, at one hundred dollars per month; one steam engineer, at eighty dollars per month; one assistant steam engineer, at sixty dollars per month; one fireman, at fifty dollars per month; one assistant fireman, at forty-five dollars per month; one conductor of elevator car, at seventy-five dollars per month; one attendant on floor, at sixty dollars per month; one attendant on top floor, at sixty dollars per month; three night and day watchmen, at sixty dollars per month each: in all, eight thousand five hundred and twenty dollars. Washington Monument. Care and maintenance.

For fuel, lights, oil, waste, packing, tools, matches, paints, brushes, brooms, lanterns, rope, nails, screws, lead, electric lights, heating apparatus, oil stoves for elevator car and upper and lower floor, repairs to engines, boilers, dynamos, elevator, and repairs of all kinds connected with the monument and machinery, and purchase of all necessary articles for keeping the monument, machinery, elevator, and electric-light plant in good order, three thousand dollars. Expenses.

FISH-WAYS AT GREAT FALLS: To complete the erection of fish-ways at the Great Falls of the Potomac, fifteen thousand dollars. Fish-ways, Great Falls.

* * * * * * *

IMPROVEMENT OF THE YELLOWSTONE NATIONAL PARK: For the improvement of the Yellowstone National Park, forty-five thousand dollars; the same to be expended by, and under the direction of, the Secretary of War: *Provided*, That fifteen thousand dollars of this amount, or so much thereof as may be necessary, may be expended, in the discretion of the Secretary of War, for the construction of a road from the Upper Geyser Basin to a point on Snake River where it crosses the southern boundary of the park. Yellowstone National Park. Improvement, etc. *Proviso.* Road to Snake River.

* * * * * * *

ENGINEER DEPARTMENT.

Engineer Department.

For continuing improvement of harbor at Philadelphia, Pennsylvania: Continuing improvement removal of Smith's Island and Windmill Island, Pennsylvania, and Petty's Island, New Jersey, and adjacent shoals, forty-one thousand dollars. Harbors. Philadelphia, Pa.

For improving harbor at Baltimore, Maryland: Completing improvement, two hundred and eight thousand dollars. Baltimore, Md.

For improving harbor at Galveston, Texas: Continuing improvement to entrance to harbor, four hundred and fifty thousand dollars. Galveston, Tex.

For improving Hay Lake Channel, Saint Mary's River, Michigan: Continuing improvement, one hundred and fifteen thousand dollars. Hay Lake Channel, Saint Mary's River, Mich.

* * * * * * *

SURVEY OF NORTHERN AND NORTHWESTERN LAKES: For printing and issuing charts for use of navigators and electrotyping plates for chart printing, two thousand dollars. Survey, northern and northwestern lakes.

For surveys, additions to and correcting engraved plates, five thousand dollars.

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Transporting maps, etc.

TRANSPORTATION OF REPORTS AND MAPS TO FOREIGN COUNTRIES: For the transportation of reports and maps to foreign countries, through the Smithsonian Institution, one hundred dollars.

* * * * * * *

Harbor of New York.

HARBOR OF NEW YORK: For prevention of obstructive and injurious deposits within the harbor and adjacent waters of New York City:

Inspectors, etc.

For pay of inspectors and deputy inspectors, office force, and expenses of office, fifteen thousand dollars:

Maintenance of steamers.

For pay of crew and maintenance of steamer Argus, eight thousand dollars;

For pay of crew and maintenance of steamer Nimrod, ten thousand dollars; in all, thirty-three thousand dollars.

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Legislative.

UNDER LEGISLATIVE.

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Library of Congress.
Continuing construction.
Provisos.
Contracts.

BUILDING FOR THE LIBRARY OF CONGRESS: For continuing the construction of the building for the library of Congress and for each and every purpose connected with the same, four hundred and fifty thousand dollars: *Provided*, That contracts may be entered into for the ironwork of stairs, roof and dome, and marble finish for halls, corridors, and rotunda, to be paid for as appropriations may from time to time be made by law: *Provided*, That Brigadier-General Thomas Lincoln Casey, now in charge of the construction of said building, shall continue in said charge until its completion whether on the active or retired list of the Army.

Gen. T. L. Casey to continue in charge.

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Public printing and binding, paper, etc.

PUBLIC PRINTING AND BINDING.

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* * * and the heads of the Executive Departments, before transmitting their annual reports to Congress, the printing of which is chargeable to this appropriation, shall cause the same to be carefully examined, and shall exclude therefrom all matter, including engravings, maps, drawings, and illustrations, except such as they shall certify in their letters transmitting such reports to be necessary and to relate entirely to the transaction of public business.

* * * * * * *

Approved, August 5, 1892.

PUBLIC RESOLUTIONS.

Feb. 25, 1892.

[No. 3.] Joint resolution investigating mining débris in California.

Mining débris, California.
Secretary of War to submit what amount should be expended to investigate.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, requested to submit for the consideration of Congress what amounts can be profitably expended during the coming year to carry out the recommendations made by the Commission of Engineers, United States Army, appointed under the provisions of an act of Congress approved October first, eighteen hundred and eighty-eight, entitled "An act to investigate mining débris in California," for "restriction works, dams and wing-dams, to restrain the mining débris where now situated, and prevent its lodgment in the rivers of California, to the injury of navigation and commerce."

Vol. 25, p. 498.

Approved, February 25, 1892.

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[No. 9.] Joint resolution authorizing the use of the martello tower on Tybee Island, Georgia, for a signal station. — April 14, 1892.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized to permit the use of the martello tower on Tybee Island, Georgia, by telegraph or telephone companies for a signal station, to report passing vessels, under such conditions as he may deem proper to protect the interest of the United States.

Tybee Island, Ga.
Use of martello tower as a signal station.

Approved, April 14, 1892.

[No. 29.] Joint resolution extending the time for the construction of a hotel on the Government reservation at Fortress Monroe, Virginia. — July 28, 1892.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the time for the construction of a hotel upon the Government reservation at Fortress Monroe, Virginia, as provided in the act of Congress approved July second, eighteen hundred and ninety, be, and the same is hereby, extended for one year from and after the passage of this act.

Fort Monroe, Va.
Time for building hotel extended.
Vol. 26, p. 213.

Approved, July 28, 1892.

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